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FLIGHT

AIRCRAFT, SPACECRAFT, MISSILES

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The New Defence

AT fitful intervals the pieces that will finally compose the jigsaw of the New Defence are falling (or being joggled and squeezed) into place; and the White Paper *Progress of the Five-Year Defence Plan* shows how the picture is being filled in. Selection of the pieces has sometimes appeared indecisive and dilatory to the point of exasperation, and recent weeks have aroused new irritations and misgivings while allaying others. For example, although an order for NA.39s has been placed on behalf of the Royal Navy, some disappointment has been voiced that this Blackburn strike/reconnaissance aircraft should not have been ordered for the R.A.F. also. To those who have advocated its acceptance in preference to the Vickers-Armstrongs/English Electric/Bristol Siddeley TSR.2 the Air Minister has explained that take-off and landing characteristics of the proposed land-based version would have been inferior to those of the TSR.2; that navigation aids would have been less adequate; that the aircraft would have cost a great deal in research and development; and that in any case it could not have been available any earlier. A suggestion that a small number of NA.39s might have been supplied to the R.A.F. for familiarization with "a new concept of air warfare" was met with a declaration by the Minister of Defence (not, it seems, precisely to the point) that it would "hopelessly delay things" if we were to wait for production of a certain number of these machines before going ahead with the TSR.2.

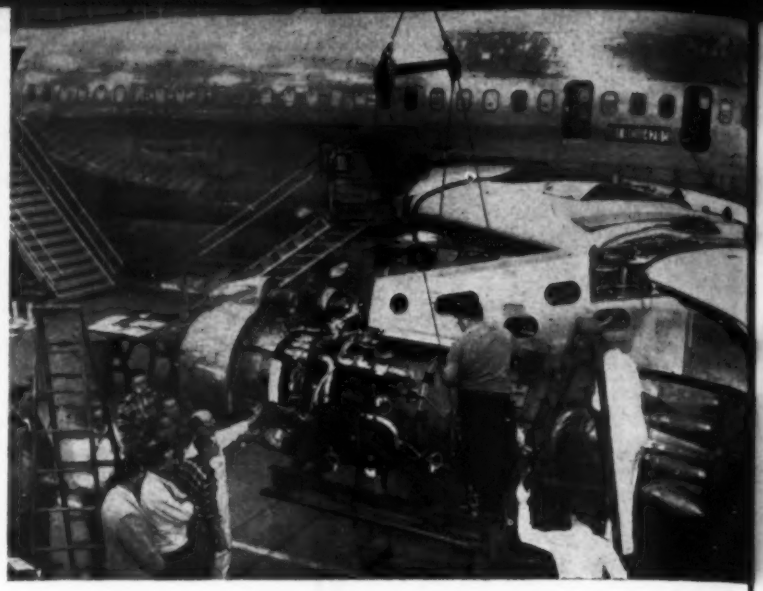
Their aspirations being thus frustrated (though prospects for export orders remain), the enterprising team at Brough sustained the crushing of another hope—irreparably in this instance—by last week's decision that the Short Britannic, and not the Blackburn B.107A, would be the new strategic freighter for R.A.F. Transport Command. In Northern Ireland there were cheers from both sides of their House of Commons when the news was given out that the contract had gone to Short and Harland at Belfast. Thus, a company with a private sorrow (that the AW.660 tactical freighter should have finally prevailed in a field where the Short PD.16 was once a strong contender) is rewarded and revivified by a contract for a freighter in a different class. Such are the permutations of the New Defence.

As we have seen, the corner of the jigsaw that will be made up of manned aeroplanes is already taking form. Whether a place may yet be found for VTO strike aircraft of the Hawker P.1127 class, or for STOL colonial machines of the type proposed in this column the other week; whether big new helicopters will find their own niche; whether there will be new types for Coastal Command and for specific Army tasks—all these engaging possibilities, we must suppose, will be deliberated in due (or overdue) time.

As for the missile complex, this has itself been more firmly interlocked by the White Paper. Having reviewed the ballistic rocket programme, the Government have concluded that Blue Streak is the type of missile best suited to British needs, and development is therefore proceeding. Thors are being deployed by the R.A.F. "for training purposes"; full-scale trials of the Bloodhound (not a rocket, this one, Mr. Sandys, as you describe it) have been under way during the past year, and Bloodhounds and Thunderbirds are becoming operational.

Thus, in so far as it deals with Service equipment, the White Paper is much in the nature of a reaffirmation and a confirmation. One disclosure, minor in itself, but having a definite interest and significance, is that the TSR.2 will be capable of carrying air-to-air missiles.

Who *was* it who said that the P.1 would be the R.A.F.'s last manned fighter?



THE RIVER LINE: The first Rolls-Royce Conway by-pass turbojet being installed recently in the first of 15 Boeing 707-420 Intercontinentals for B.O.A.C. Rated at 17,000 lb, the Conway will also be used on 707 Intercontinentals ordered by Lufthansa, Air-India International, and Varig Airlines of Brazil. Deliveries to B.O.A.C. will begin later this year. It was announced last week that later Conways will, as a result of recent A.R.B. approval, be rated at 18,000 lb "minimum dry" thrust. For 707s Rolls-Royce supply the complete powerplant, reverser, nozzle and nacelle

FROM ALL QUARTERS

Battle of the Navaids

UNUSUALLY wide daily-paper coverage has been accorded to the "Anglo-U.S. Air Fight" (as one newspaper called it) which has now been "looming" in Montreal for nearly a fortnight. Despite an appeal by Mr. Walter Binaghi, president of the I.C.A.O. Council, that emotions should not be allowed to cloud the technical picture the preliminary skirmishes were conducted in an atmosphere of some tension and the main council chamber was crowded to the doors. The 35 States present include "safe" U.S. voters, Bolivia, Ecuador, Colombia, Nicaragua and Korea. The Decca-equipped Comet 2E, fresh from its official demonstrations in Europe and America, is standing by at Dorval to demonstrate Decca capabilities.

A British suggestion that the short-range aid should be considered in relation to the long-range aid—Decca and Dectra are complementary systems—was heavily defeated when put to the vote. The British delegation distributed a working paper which noted that the American case was supported by a comparison of Vortac with a Decca receiver which was "eight years old, never used in civil airlines and not designed for that purpose" although the writers (Air Transport Association) could not have been unaware of Decca Mk 10, on which British support is based. American statements elsewhere were dismissed as "completely incorrect," "peculiar," "difficult to follow" and "completely incomprehensible."

I.A.T.A., whose decision in favour of Vortac was recorded in a *Flight* leading article for February 6, has stated that it considers that VOR will suffice as the sole standard for many years, so long as airspace capacity is used effectively. Distance measuring, it continues, is needed "only in certain high traffic density areas and other locations where distance measuring ability is needed to improve traffic control." DMET should be standardized to provide distance measuring "when and where required."

Capt. W. M. Masland, of Pan American, presented a working paper on behalf of I.F.A.L.P.A. which unequivocally stated that association's disapproval of VOR and supported area-coverage.

The I.C.A.O. meeting has divided into two committees, one investigating the requirements for air traffic control and navigation and the other making a comparative assessment of Vortac and Decca. Both Britain and America seem to be moderating their proposals in order to avoid an Anglo-U.S. showdown, though without actually changing their positions. A decision may be deferred altogether, pending "technical improvement" of the aids. Time is, of course, on the American side, because the installation of Vortac is continuing inexorably, both in America and Europe.

B.O.A.C. Round the World

LAST week B.O.A.C. announced that their first round-the-world services, which have been in the planning stage for some time, will be inaugurated on April 1.

Comet 4s will fly eastwards from London to Hong Kong and Tokyo, linking with Britannia 312s which will fly the west-about route from London. The announcement suggests the imminent approval by the American Government of B.O.A.C.'s application to extend its Britannia services from San Francisco across the Pacific to the Far East. American carriers have strongly opposed this application.

If approval is forthcoming the first Britannia service will leave London on March 31 for Tokyo and Hong Kong via New York, San Francisco, Honolulu and Wake Island. The first Comet 4 service to Hong Kong and Tokyo, as already announced, will leave London on April 1. The two British airliners should pass each other somewhere between Hong Kong and Tokyo on April 3.

On one of the four Comet 4 services each week there will be a connection—after a stopover of three hours at Hong Kong—with a Britannia 312 flying to London in a scheduled time of 57 hr 50 min (including a 12 hour stop at San Francisco). By Comet 4 to Hong Kong is 26 hr; thus the round-the-world B.O.A.C. journey eastbound will take just over three and a half days. In the opposite direction the connection will also be made at Hong Kong but, because of schedule differences, the journey will take four and a half days.

Plans are in hand to speed up the eastbound service so that passengers may complete a round-the-world trip, should they so wish, in 80 hours.

Royalty Earnings

REVENUE received by the British aircraft industry from its 41 overseas licence agreements totalled some £30m during the six-year period 1952-57. This figure includes the sales of certain components and parts necessary for the construction of the airframes or engines concerned.

Of the total, some £12m worth is accounted for by royalties alone. The highest royalty figure was in 1954 (£3,231,341) and the largest total for components was £7,007,000 in 1956. For 1957, only the royalty total (£1,467,845) is available, but it is likely that the combined figure for royalties plus components and parts will amount to at least £5m.

Over the past ten years or so, 19 agreements have been made with 11 countries for the manufacture of nine basic types of British aircraft; and a further 22 agreements signed with ten countries for the manufacture of 12 types of aero-engine. The great majority of these licence arrangements are in current operation, a number of them having been signed during the past twelve months.

Anti-Collision Liveries?

AFTER trials lasting about ten months, the M.T.C.A. have decided to paint their fleet of 15 small aircraft—Chipmunks, Doves, Presidents and Princes, based at Stansted—in a new livery incorporating orange fluorescent "Day-Glo" paint. At London Airport last Monday Mr. John Hay, Joint Parliamentary Secretary to the M.T.C.A., described the fluorescent paint as having a "modest but important" part to play in improving air safety by increasing the conspicuity of the aircraft. Aircraft of the U.S. Federal Aviation Agency are already treated in this manner.

Two aircraft demonstrated by the M.T.C.A. at London Airport, a Dove and a President, had panels of Day-Glo paint on their spinners, wing-tips, centre sections, cheat-lines, rudders, dorsal fins and tailplane tips. The fluorescent paint is applied over a white undercoat and is protected by a coat of special varnish. The M.T.C.A. said that treating the President cost about £100, including the design, and that they hoped that the paint would remain effective for about six months, although this estimate is considered by the manufacturers, Dane & Co., to be conservative; their experience, they say, indicates that probable life is nine to sixteen months.

Although the Ministry are not yet insisting upon the use of fluorescent-paint panels on British transports, they are recommending it to the Corporations and to the independent airlines, who are studying it in relation to their colour schemes. Hunting-Clan have already decided to use it on all their aircraft; their DC-6s will be operating in "rocket red" Day-Glo next week.

FINAL ASSEMBLY at Folland Aircraft's Hamble works, showing Gnat Mk 1s. In the foreground are coupled front and centre fuselages, as received from the dispersal plant at Southampton Airport. From the far end Gnats are sent to Chilbolton for test. A total of 59 Gnat 1s are on order, from the M.o.S., India, Finland and Yugoslavia. Fourteen Gnat Trainers are being built, on a pre-production contract, for the R.A.F.

Omnipresident

CLOSED-CIRCUIT TV was used by the Royal Aeronautical Society to relay Sir Arnold Hall's address to 480 guests at his presidential reception last Friday. Six screens, each about 8ft above floor level, were set up in the Society's headquarters at Hamilton Place, London, W.1—three in the library, two in the council room and one in the committee room. As a result, the guests could all see and hear the president—who broadcast from the committee room—in reasonable comfort.

Sir Arnold referred to the contributions the Society had made, and was continuing to make, towards the advance of aeronautical science and technology. He spoke of its membership of 10,550, with branches both in the U.K. and overseas; of the influence of the Society's publications; and of its links with aeronautical bodies abroad.

Traffic Control Officers Meet

AT the fifth annual general meeting of the Guild of Air Traffic Control Officers in London last Saturday the retiring Master, Mr. W. C. Woodruff, installed his successor, Mr. K. I. Pearson, who is senior air traffic control officer at R.A.E. Farnborough. Mr. G. L. Chambers was re-elected as clerk and Mr. G. C. Burch as treasurer. The meeting was followed by a dinner at the Dorchester, at which the guest of honour was Air Marshal Sir Geoffrey Tuttle. Capt. V. A. M. Hunt presented a new trophy for "the most outstanding contribution to air traffic control during the preceding year." First winners are the M.T.C.A. School of Air Traffic Control, with Southend A.T.C. as close runners-up.

Neville Spriggs Leaves Hawker

IT is learned that Mr. A. Neville Spriggs, O.B.E., M.I.P.E., managing director of Hawker Aircraft Ltd., has relinquished his appointment with the company after 44 years' service (he joined Sopwith as an apprentice in 1915). It has been announced that his retirement is due to a complete reorganization of aviation companies within Hawker Siddeley Aviation Ltd., the statement continuing: ". . . as a result of which it was decided that there was no position open to him commensurate with his rank."

London's Second Heliport

UNTIL as recently as a few months ago London was in the invidious position of being one of the few major European capital cities without a central heliport site. Next week, if a public inquiry gives approval to proposals put forward by Rotorports Ltd., Britain's capital will find itself the proud possessor of two sites within three miles of each other.

The Rotorports site is a disused wharf on the Thames south bank close to Vauxhall Bridge and adjacent to British Railways' Nine Elms goods depot. The directors are confident that this is one of the three possible sites favoured by the London County Council, the other two being situated to the north of King's Cross station and to the east of the Tower of London.

Unlike the T-shaped landing platform favoured by Westland at their nearly completed Battersea heliport, the Rotorports design is based on an almost rectangular platform measuring some 150ft×120ft. This platform will be raised above ground-level as a precaution against flooding and will extend well out over the water and some way on to the actual site.

Rotorports do not plan to operate air services under their own name. In the immediate future they intend to develop the market for business travel, using either a Westland Widgeon or a Bell 47J under the colours of an associated company, Executair. Looking farther ahead, it is hoped that the advent of suitably economic aircraft will permit the operation by Executair of scheduled passenger services.

NEW REAR ASPECT of the Saab Draken supersonic fighter-attack aircraft (Rolls-Royce Avon) shown in this picture of the 35A version. The fuselage is longer and retractable dual tailwheels replace a bumper

KNIGHTED at Buckingham Palace on February 10 was Mr. Aubrey F. Burke, deputy chairman and managing director of the de Havilland Aircraft Co. Ltd. Sir Aubrey is seen after the ceremony with Lady Burke and their son Kevin. Sir Aubrey is also chairman of the de Havilland Engine Co. Ltd., and deputy chairman of de Havilland Holdings Ltd., the parent de Havilland company. He is managing director of the recently formed Aircraft Manufacturing Co. Ltd.

IN BRIEF

An increase in funds has been provided by the Government for the development of the Short SC.1. This was stated in Parliament last week by the Minister of Supply, Mr. Aubrey Jones.

* * *

Mr. H. E. Drew has been appointed Director of Electronics Production (Air) at the Ministry of Supply in succession to Mr. R. E. Sainsbury.

* * *

Mr. Peter Masefield, managing director of Bristol Aircraft Ltd., Mr. Percy Hunting, chairman of the Hunting Group, and Mr. Hugh Actor, a director of *The Times* and a qualified helicopter pilot, have been appointed members of the council of the Air League. Sir Miles Thomas, chairman of Monsanto Chemicals Ltd. and a former member of the council, has accepted an invitation to become a vice-president.

* * *

Miles Electronics announce that they have been awarded the contract for the design and manufacture of a simulator for the Blackburn NA.39. The company have recently completed a simulator for the flight refuelling of V-bombers, and a Sea Vixen simulator is in progress.

* * *

At the Royal Festival Hall, London, last Saturday, three of the four members of *The Small World* balloon crew gave a well-attended lecture on their transatlantic flight. The provincial lecture tour announced last week has been postponed.

* * *

Today's (February 20) issue of our associated journal *The Autocar* is a special "Choosing Your Car" number, giving all the information and guidance necessary to ensure that the vehicle bought is right in performance, economy and convenience. The price of the issue is 1s as usual.

BRITANNICS ON ORDER

Tyne-Powered Short Freighters for the R.A.F.

SO that Transport Command would be equipped for carrying especially heavy and bulky loads, the Government some time ago decided to buy a number of long-range freighter aircraft. This decision was confirmed in last week's progress report on the Defence Plan; and in the Commons on February 11 the Minister, Mr. Duncan Sandys, disclosed that the type selected was the Britannic 3, a freighter version of the Britannia to be built by Short Brothers & Harland Ltd. of Belfast. Loading arrangements, added Mr. Sandys, were in accordance with the Army's requirements; and in terms of speed and performance the aircraft would "fit in very well with the Britannias, which are to carry the troops and the less bulky freight."

There were two reasons for delay in placing the order: (1) the requirement had to be considered very carefully not only inside the Government Departments concerned but also with the industry; (2) it was thought right to try to choose an aeroplane which would not only meet military requirements but might also have a civilian market.

Known within the firm as the SC.5, the aircraft is based on the use of the Britannia wing and systems (already in production at Belfast) and on a specially designed fuselage of very large dimensions and with a rear-loading door. Four Rolls-Royce Tyne turboprops are specified. The company state: "Project design work has been in hand for over eighteen months, detailed market survey of the precise needs of military and civil operators for more than a year; and the design itself has been actively pursued for some six months. Design and development are proceeding according to plan and the first prototype is due to fly in April 1961. Production plans are being studied at the moment and it is hoped that production aircraft will become available towards the end of 1961 or early in 1962. The use of many Britannia parts in the SC.5 means that it can be developed at much less cost than an entirely new aeroplane. It would also mean reduction in the cost of providing spares and maintenance bases along the routes over which it would operate alongside Britannias, and would shorten the training both of flight and ground crews."

As a result of their market survey Shorts are confident that, due to its low operating cost, the Britannic can offer civil operators important new possibilities for long-distance freighting by 1963 or 1964. The aircraft uses the standard Britannia wing and tailplane; an undercarriage almost identical with that of the Britannia, but installed in the fuselage; and many of the standard systems such as fuel, controls, electrics and the flight-deck installation.

The fuselage is 17½ft in diameter and the floor is at "truck-bed" height. Clear hold dimensions are 12ft × 12ft × 80½ft and design gross weight is 195,000 lb. A maximum payload of 75,000 lb can be carried at a mean speed of 360 m.p.h. over a still-air range of 1,400 miles. With full fuel, a 30,000 lb payload can be carried over 5,500 miles. The aircraft is capable of delivering a 33,000 lb payload to a 1,000-yd strip 860 miles from its main base, returning either empty or with a 30,000 lb load. The Britannic is pressurized to maintain a cabin altitude of 8,000ft at all altitudes up to 30,000ft; the rear door can, however, be opened in flight for parachuting large loads.

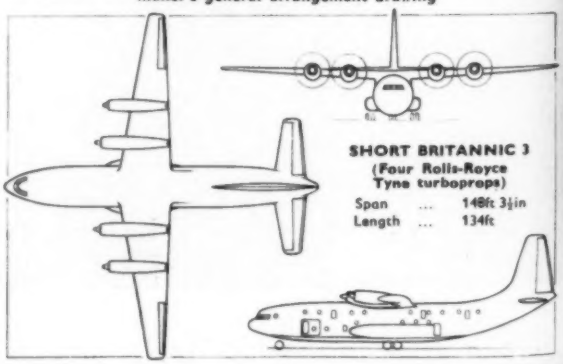
Behind the flight deck is a permanent galley and lavatory section and a staircase leading to an upper deck. In the troop transport rôle a detachable second floor can quickly be fitted to the forward end of the fuselage hold, allowing about 200 troops to be carried in comfort. Normally, 140 troops can be carried on the main floor without fitting the second floor. In addition to the freight-floor of the hold itself, which is 60ft long, there is a further 20ft length of sloping floor, 12ft wide, which forms the loading ramp and can be used for loading and carrying freight. Headroom on the centreline at the extreme aft end of this floor is 10ft 6in.

The ramp loading door is controlled by hydraulic rams. Vehicles can be driven up the ramp, or the ramp can be lowered part way so as to rest on the bed of a lorry and provide an approach for loading. To facilitate the loading of smaller freight, a side door 7½ft × 8½ft is provided in the fuselage at the forward end of the hold. A grid of standard lashing points extends over the interior floor and up the side of the wall to a height of 4ft. The permissible load alternates between 5,000 lb and 10,000 lb on the floor and is 2,000 lb on the walls. Further points of 25,000 lb and 35,000 lb are provided for special requirements.

Typical loads would be: two 1-ton trucks (laden), two 25-pdr guns, one scout car (laden); or four 1-ton trucks (laden); or three 3-ton trucks (laden); or two scout cars (laden), two ¼-ton Utilities (laden) and two ¼-ton trailers (laden). Special vehicles which could be handled include a 30-ton heavy artillery tractor, 10-ton Albion crane, 10-ton Leyland refueller, and large radar trailers used with guided-missile installations.

As a passenger transport the Britannic can carry the capacity payload of 197 passengers at 356 m.p.h. TAS over an ESA range of 2,600 miles for a direct operating cost of 0.77d/seat-st. mile. With capacity fuel 90 passengers can be carried at 356 m.p.h. TAS over an ESA range of 5,450 miles.

On the left is seen the Britannic's rear-loading facility, and below is a maker's general-arrangement drawing



AIR COMMERCE

Systems for the VC.10

UNDER pressure of competition, a great deal of energy and private money is being expended by the accessory firms on systems for the VC.10 and D.H.121, and a lot of it is going to be brought to naught when the final choices are made. To add an extra chill to the winter of the losers' discontent, some of the equipment for the VC.10 is going to be of American design.

How are decisions made on the type of equipment to install? And, it may be asked, do not B.O.A.C. (who are required to accept the onus of developing the relevant products of British aircraft manufacturers) also have a responsibility to the British component industry? Or, in the light of previous experience with some British systems, is there a backlog of prejudice that has swung airline opinion towards American equipment and systems?

These questions highlight the difficult position in which B.O.A.C. has been placed by the VC.10, for which certain American equipment, as used in the Boeing 707, has been chosen. As an airline, their object is to operate a public service, and to make money by operating the most suitable type of aeroplane for their needs as economically and efficiently as possible. They have asked for—but have certainly not received—Government development contracts for putting British civil aircraft into initial service. They have accepted this responsibility as being in the interest of the nation, if not necessarily of the airline. And they will accept, if they must, responsibility for the development of new systems.

The Corporation's expressed preference is for "Any component which can do the job, provided there is operating experience behind it." Only if the risk is small and the consequences of failure are slight are they prepared to develop an untried system.

This attitude of mind is shared by the aircraft designer. The responsibility of the manufacturer as "prime contractor" for the equipment he installs is now taken very seriously indeed. This is a process of growing-up in the civil aviation business, and British manufacturers are rapidly acquiring the *savoire-faire* of Lockheed, Boeing and Douglas in this respect. The U.S. technique, now closely followed by the designers of the VC.10, is to write detailed specifications for every system, and every component of each system, embodied in the aircraft project.

The prime contractor must undertake ultimate responsibility for the successful operation of the aeroplane in service. The choice of each system is the carefully weighed decision of the aircraft manufacturer, who writes it into the specification which forms the contract between the maker and the airline customer. Of course, the airline is in consultation with the manufacturer's systems engineers during the planning of the aircraft, and certain equipment—seats, furnishings, radio and so on—is customer-supplied. But because Vickers are going to be responsible for every item of equipment in the aircraft once it is in service, as prime contractor they carry out a detailed investigation into the most suitable system—from the points of view of functioning, reliability, simplicity, cost, operating and field servicing experience, and above all, on-time delivery.

This is a process of exact specification, tender and (initially at least) 100 per cent component and system acceptance test to a manufacturer-devised schedule. In fact, the chief engineer of B.O.A.C., Mr. Charles Abell, has recently said that the Corporation have probably specified less actual equipment for the VC.10 than for any previous aircraft they have ordered, although they have written specifications stipulating what certain systems must be capable of doing. Vickers must then ensure that the equipment installed meets this specification.

Thus, although the choice of system is a technical one, it is not only efficiency or weight or even availability that governs the decision to buy one system or reject another. The engineer experienced in the requirements of the civil market must weigh attractive advantages of a purely engineering nature against the satisfaction that can be expected in service.

With only limited civil-aircraft engineering experience behind them (in the stringent airline sense) not all British component manufacturers have assimilated the lessons that are needed to bring them civil business now. Nor have there been opportunities for the accumulation of operating experience in either civil or military aircraft on anything like the scale afforded to rival manufacturers in the U.S. The field of component competition is international, and Vickers' choice of a limited amount of American-designed equipment for the VC.10 is no reflection on British design ability, whatever handicaps it may impose on the development for service of new British systems.

Nor does the use of American equipment imply a total loss of British business, since the DB-20 Bendix autopilot is to be built by Elliott, Sundstrand constant-speed drives are to be supplied by English Electric, and Westinghouse alternators will come from Plessey. Many other major systems will offer outlets for the best the British industry can produce. Powered flying controls, in which field this country is probably abreast of development in the U.S., will be supplied by Boulton Paul, feel systems by Hobson, fuel systems by Lucas and radio by Marconi; and there will be other systems—pneumatic starters, A.P.U.s, air conditioning equipment and so on—by other British firms.

It is an engineering truism that components initially common to two types of aircraft never remain identical for very long; development to suit a particular aircraft may soon require substantial improvement and redesign. All the U.S. designed equipment mentioned above has been proved in service and will be used first by B.O.A.C. in their Boeing 707s. Its adoption appears logical, and, as in many previous instances in the history of the British aircraft industry, development under licence from a U.S. manufacturer may bring substantial rewards—D.H. Propellers are an appropriate example.

All this does not preclude development work by manufacturers whose systems have not been chosen for either of Britain's two new jet airliners. But it seems unlikely, unless the already chosen equipment proves unsatisfactory, or unless engineering advantages can be offered which are so great that they make an integrated system change-over worthwhile, that much immediate prospect for civil business exists. Yet because aeronautical progress in the long term is no less rapid than it has been before, the design and development of new systems is required as much as ever. In doing business in a competitive field that acknowledges no national boundaries, greater commercial risks have to be taken to earn the same rewards.

A. T. P.

At London Airport last week Air France celebrated the 40th anniversary of a French air service operated on February 8, 1919, by a Farman Goliath between Paris and London. M. Max Hymans, Air France president, is seen at the luncheon introducing Lord Douglas, B.E.A. chairman. On this occasion was announced the conclusion of a five-year pool agreement between the two airlines on the London-Paris and London - Nice routes (see article overleaf)

"Flight" photograph

TOWARDS AIRPORT SELF-SUFFICIENCY?

THREE years have elapsed since a hard-hitting Parliamentary select committee reported on the financial management of Britain's state-owned airports.

A year later the Ministry published a guarded comment on the report. But in the subsequent two years most of the recommendations appear to have been adopted. Revenue and expenditure accounts are now published, and it has become possible for outsiders to measure the extent of airport subsidy. Landing fees were increased, and this would have increased the revenue obtained from airport users from £2.3m in 1957-58 to £3.2m in 1958-59, had it not been for the business recession. Recent months have also seen increasing evidence of the Ministry arranging to transfer provincial airports to local authorities.

The latest proposed move towards self-sufficiency was announced last week by the Minister: landing fees are to be increased by 28 per cent and the passenger service charge (introduced in 1952) will be raised from 5s to 7s 6d. These changes should raise an additional £660,000 and £220,000 respectively. Despite the fact that most of this will accrue to London Airport, it still appears that this facility will lose at least £2m in the coming year. And although total U.K. traffic will have doubled between 1954 and 1959, it seems unlikely that the overall loss on British airports in 1959-60 will be below the 1954-55 level of £6m.

AIR COMMERCE . . .

B.E.A.'s COMPETITION

A Review of the Corporation's Pool Agreements

by J. M. RAMSDEN

THE news last week that B.E.A. have concluded a traffic-pool agreement with Air France came a few weeks after the conclusion of a similar agreement with Swissair. When these pacts come into force, on April 1, B.E.A. will be operating in pool with 13 of their 14 European rivals. This article discusses the case for and against pooling.

THE fact that B.E.A., as from the first day of their 1959-60 financial year, will pool their revenues with Air France and Swissair may not, on the face of it, seem particularly remarkable: pool agreements are common enough in international air transport. Yet it is of interest, because it means that an airline which justly claims the finest air fleet in Europe, and which fought vehemently for a big fleet of jets to preserve its competitive position, will soon be sharing its earnings with 13 out of its 14 European rivals.

Up to 1952 B.E.A. firmly shunned pool agreements. Since that time the Corporation has agreed to pool services with all its European competitors but one, as follows:

Aer Lingus, Air France, Alitalia, Austrian Airlines, C.S.A., Iberia, K.L.M., L.O.T., Lufthansa, Olympic Airways, Sabena, S.A.S., and Swissair.

The one exception is the Portuguese airline T.A.P., which is, it is understood, examining the advantages of a pool agreement with B.E.A.

At a rough estimate, as much as 90 to 95 per cent of B.E.A.'s international business, in terms of passenger-miles flown, is subject to restricted commercial competition from European airlines. Competition from non-European airlines—the long-haul foreign carriers which traverse B.E.A.'s routes with U.K. traffic rights—must of course be taken into account to obtain a true picture of B.E.A.'s competition. But, for the moment, it is worth examining the reasons for the surprisingly small extent of the commercial competition between B.E.A. and its main rivals—the European airlines.

The Background to Pooling

The extent of B.E.A.'s pool agreements is perhaps not generally appreciated because, contrary to B.E.A.'s traditional policy of "full information" (no other airline publishes so much about itself), the Corporation rarely draws attention to pooling. The subject has never been mentioned in an Annual Report, and only twice—and then rather delicately—in 50 issues of the monthly B.E.A. Magazine. The pool with Air France was the first for some years to be announced; previously it had not been the Corporation's policy to publicize the conclusion of a pool agreement, except to the travel trade, and rarely had any public statement ever been issued by the other airline concerned.

It is perhaps not difficult to see why airlines avoid drawing attention to their pool arrangements. The words "monopoly" and "cartel" are suspect in any form of commerce. They are applicable when producers of a similar commodity join up together to limit price and output, thus depriving the consumer of the improved-service benefits of competition, and theoretically keeping prices at an artificially inflated level.

International air commerce, by reason of the protective attitude of governments, is particularly vulnerable to cries of "Monopoly! Cartel! Let there be free trade!" But—pooling apart for the moment—it is not really the fault of the airlines that, through I.A.T.A., they fix their prices. Nor that, by the terms of inter-government air agreements, they very often have to limit also their output (i.e. capacity). These are the as yet inescapable political conditions of international air commerce. Accusations about restrictive practices, therefore (pooling apart still), should be referred not so much to the airlines as to governments. The political atmosphere in which the airlines have to fly, the Five Freedoms of the Chicago Convention, the bilateral air agreements and so on are all manifestations of the doctrine that all nations have sovereignty over their air space.

Yet the political restrictions still leave considerable scope for spirited airline competition and commercial enterprise. There remains the competitive incentive to win traffic from the opposition by offering better service to the public; a sense of competition is felt throughout every department, and the airline is on its toes—to the advantage of consumer and airline alike.

There are of course limits to the value of competition. If not sensibly regulated it can be exceedingly wasteful. But when two airlines decide to pool their services the acknowledged benefits of reasonable competition can be eliminated or—depending on the precise nature of the pool agreement—considerably diminished.

There are various types of pool agreement, all differing in detail, but each based upon the same underlying principle—namely that the revenue earned by each operator is shared with the other in proportion to a predetermined rate. It is not difficult to imagine how such an arrangement might well tend to relax the effort to be competitive and efficient, and why some pools have been described by a former B.E.A. chief executive as "the lazy way out."

No matter how many safeguards are provided (in a minority of B.E.A. pools, for example, earnings over and above an agreed load factor can be kept as a competitive stimulus), there appears to be something commercially relaxing about a system which in essence allows one airline to benefit from the efforts of a "competitor." (In America, incidentally, airline revenue pools are non-existent; the U.S. Civil Aeronautics Board forbids them as contrary to the public interest.)

It is understandable that some of the smaller and less efficient carriers might desire to pool services. But it is not readily obvious why B.E.A., the largest and best equipped of all intra-European carriers, should have entered into so many pool agreements—13 in all—over the past six years.

A number of possible explanations must therefore be considered. The following are the main commercial arguments for pooling:

(1) Pools prevent the scheduling of excessive capacity—the most usually wasteful result of airline competition—and thus produce higher load factors.

(2) Pools permit mutual economies in such expensive items as traffic staff, other station costs, and sales, promotion and advertising.

(3) Pools provide the public with a more convenient spread of services throughout the day, avoiding attempts by competing carriers to "hog" peak times, thus leaving little or no service at other times.

These are the commercial—as opposed to political—arguments for pooling. How supportable are they?

(1) That pools achieve higher load factors is not the positive conclusion of the Air Research Bureau (the air transport organization of which B.E.A. and most intra-European airlines are members). In their August 1955 report on *Intra-European Air Passenger Traffic* the following table appeared (p. 30):—

Pool Traffic 1951 to 1953, A.R.B. carriers

	Passenger load factor (per cent)		
	1951	1952	1953
Pool traffic	54.6	54.4	51.8
Other traffic	60.8	58.7	58.8
Total traffic	59.5	57.9	57.4
Pool load-factor as percentage of other ...	89.8	92.7	88.1

It will be seen that pool-traffic load factors are appreciably less than competitive-traffic load factors. Commenting on this (p. 6), the report said: "The load factors on pool routes are on average lower than on others, but it should not be inferred that pools as such tend to reduce the load factor. Rather, it is an indication that pool arrangements are made between carriers on competing routes where the load factor has been relatively low. *However* [our italics], *pooling arrangements themselves do not seem to stimulate traffic growth to any greater extent than the average.*"

B.E.A.'s experience has, it is believed, been that pools have boosted passenger load factors on the routes concerned. But on *total* B.E.A. traffic since 1954/55 (when results of the first pools took effect) the evidence is not altogether conclusive: total passenger load factor was 68.4 per cent in that year compared with 68.5 per cent in 1957/58.

(2) Mutual economies in station costs can be achieved without pools. The avoidance of duplicated traffic-handling staff, equipment and facilities at each end of a route is obviously in the interests of both airlines, and can be—and is—made to work without a pool agreement. So far as sales and publicity costs are concerned, most European airlines are world-wide operators (B.E.A. act as B.O.A.C.'s agents in the majority of European cities), and they cannot rely on another operator to promote their other business satisfactorily. The existence of a pool does not mean that an airline can haul down its flag in the country

concerned, and leave its interests to the pool partner. It might even be said that because the value of a pool needs to be constantly reviewed, vigilant foreign representation remains essential.

(3) Sensible timetable agreements can be—and are—achieved without pools. The London - Paris route is a good example of well spread frequencies achieved without a pool agreement. Admittedly this particular route is operated at high frequency (by European standards), and it therefore lends itself relatively easily to timetable agreements. But, in general, a "frequency pool" should be attainable without the deeper commercial immersion in a revenue pool. There is one qualification: B.E.A., as intra-European specialists, are unique among their rivals in that they cannot "cross-subsidize" any of their routes as feeders for long-haul services. Some of their competitors do so, however. In the case of London - Amsterdam and London - Brussels, for example, B.E.A. could not afford to match the frequencies offered by competitors who are concerned with pulling traffic into their more lucrative long-haul services. It was probably this situation which led to the pools with K.L.M. and Sabena.

But it is hard to imagine that B.E.A. have willingly entered into agreements which inevitably involve some surrender of commercial initiative, and expose the Corporation to suggestions that its commercial policies are softer than they might be. There must be other reasons.

In seeking these it is worth noting that the extent of B.E.A.'s pooling appears to have been a direct function of improvements in their aircraft equipment. The first pool agreements followed the replacement of Vikings by Elizabethans, and more pools followed the introduction of the Viscount in 1953/54. This strongly suggests that at least some pools must have had their roots in politics. Such is the political background of international air transport that the following sort of situation can, and sometimes does, arise.

Carrier A and Carrier B operate services between countries A and B. The capacity offered by A and B on these services is in accordance with the Air Agreement negotiated between the two governments. All goes well until Carrier A introduces a highly competitive new aircraft and sweeps in all the traffic. B requests a pool. A refuses. So B complains to its government—which is highly protective towards its flag carrier—and government B suggests to government A that since Carrier A will not agree to a pool their Air Agreement must be "reviewed."

Thus can political pressures be brought to bear; and though it is not suggested that this is a common sequence of events, it is indicative of the possible political background to at least some of B.E.A.'s pool agreements.

Political Bargaining

But there may be a flaw even in this "political" reason for B.E.A.'s pools. If the carriage of international traffic is founded, as indeed it is, upon a system of political bargaining, B.E.A. should be able to bargain from a position of strength. The United Kingdom, as the biggest traffic-generator in Europe, has more to offer than its neighbours. This prompts the thought that pools need not always be forced upon B.E.A. for political reasons, because the Corporation should normally be able to feel confident that, if it comes to a political showdown, the United Kingdom stands to come off best. In this respect B.E.A. vicariously benefit from the U.K. traffic rights enjoyed by European airlines (all of whom, unlike B.E.A., are in the long-haul business) in competition with B.O.A.C.

There is, however, another kind of political pool, which might be termed the "entry-fee" type. Three or four out of the 13 B.E.A. pools are arrangements whereby the Corporation in effect pays a smaller competitor for the freedom to run as many services into his country as the traffic will bear. This freedom is "bought" by guaranteeing the competitor's services an agreed load factor. Such pools are usually those with airlines whose countries are popular with U.K. tourists. By means of such "entry-fee" pools there is no doubt that B.E.A. have considerably expanded their business on a number of holiday routes—to an extent which would otherwise have been impossible, and with the acquiescence of the country concerned.

This type of pool, though perhaps rather unacceptable to the economic purists, is easiest to justify: the end-product is increased business and revenue for B.E.A. It is open to just one criticism. Why should B.E.A. pay out to a competitor for the right to open up his country's lucrative tourist trade? He seems to be getting the bun and the halfpenny. Cannot B.E.A. argue that they are bringing in valuable business, all of it originating in the U.K., and that to tax it is unreasonable? No doubt B.E.A. do argue thus; but the quick rejoinder might well be: "It is because our country is so delightful that your people come here, therefore we have the right to a share in the air business." Whether or not, as tourism develops, B.E.A. are right to agree to a permanent entry fee is an arguable point. But on balance it seems fair to say that such pools are easier to justify than some others. They obviously need to be especially carefully reviewed.

It is thus by no means fair to label all pools as "the lazy way out": in the special circumstances of European air transport it is possible to find convincing justification for four, five or perhaps six of the 13 pools entered into by B.E.A. What of the others?

It seems reasonable to suggest that not only does the evidence for the commercial justification of these appear to be in some doubt, but the political justification for them is in some doubt also.

Three quotations are relevant here. The first was made by B.E.A. themselves four years ago. Mr. Peter Masefield, then chief executive of B.E.A., writing in the *B.E.A. Magazine*, August 1954, said:—

"There are places where international competition is better commercially for a strong airline and there are places—rather less of them—where pooling is better than competition for the same airline. Till recently we have set our faces against pools—and I believe that our judgment has been right."

Again, more recently, in the issue of December 1957, Lord Douglas, chairman of B.E.A., wrote:—

"Although pooling, in some cases, has the advantage of rationalizing frequencies and capacities, I hope no one will get the idea that it is the 'cure-all' for all routes. It certainly is not that—there are undoubtedly routes on which straight all-out competition is the right commercial course. Every route must be judged on its merits."

The third was made in 1953 by Swissair—the airline with which B.E.A. recently concluded a pool agreement:—

"Swissair remains well aware that entrance into pool agreements does not bring unmixed advantages. The simplification and economies of operation resulting from such arrangements are often offset by limitations on free initiative. Wherever possible, Swissair prefers to seek its growth in an atmosphere of free competition."

For every anti-pool quotation it is possible to find one which is pro-pool. And times change quickly in aviation: words uttered today are often eaten tomorrow.

But what changes have caused B.E.A. to pool, and thus protect from real competition, up to 95 per cent of their international passenger business? The Corporation cannot fear competition: it operates, and can be assured that it will always be provided with, the world's most competitive equipment. It is backed by a Government with Europe's strongest air-agreement bargaining powers; and it is guaranteed by Parliament the British monopoly of scheduled services (incidentally *because* of foreign competition).

It must of course be fully acknowledged that B.E.A.'s traffic has expanded at a rate very much higher than the world average over the past few years. And the Corporation is fully committed to a policy of reducing fares by 15 to 20 per cent in 1959/60. This is not exactly evidence of an unenlightened commercial policy.

But while some pools are undoubtedly necessary, a "pool-everything" policy must inevitably diminish the effort to be competitive and efficient; it must mean the destruction of the precious little freedom which politics allow to an airline; and it must undeniably lead to questions about cartels.

The suggestion is that, unexposed to such implications of a "pool-everything" policy, B.E.A. would be an even more enlightened airline than it already is.

Summary

- *B.E.A. will soon operate in pool with 13 of their 14 European rivals.*
- *Probably as much as 95 per cent of B.E.A.'s international business will thus be subject to little or no European competition.*
- *Pool agreements are rarely announced by B.E.A. or their partners, and are only rarely referred to. In America they are not permitted.*
- *In the economic sense a pool agreement is a cartel, more so even than fare-fixing and capacity-fixing.*
- *The main* commercial *arguments for pooling do not appear to be convincingly supportable, except possibly those concerning routes which B.E.A.'s competitors "cross-subsidize" as long-haul feeders.*
- *The* political *arguments for pooling are also open to some debate: an exception may be the "entry-fee" pool whereby freedom to expand is paid for by guaranteeing the competitor his loads.*
- *On balance, a large proportion of B.E.A.'s 13 pools—perhaps more than half—may not be convincingly justifiable either commercially or politically.*
- *It is indisputable that B.E.A.'s business has increased at least as much as—and in many countries more than—that of its rivals, and that some of the Corporation's pools are justifiable. But it is suggested that B.E.A.'s almost total commitment to pooling may—to use B.E.A.'s own words of little more than a year ago—not be "the right commercial course."*

AIR COMMERCE . . .

THE ELECTRA'S ALTIMETER

AN order made last week by the F.A.A. lifting the voluntary restriction imposed on the Electra's landing minima, on condition that the type of altimeter is changed, clearly raises suspicion that the Electra accident in the East River may be yet another attributable to instrument misinterpretation. (See "Altimeter Change-over," *Flight*, last week). A glide-path height reference was not available to the American Airlines Electra on its I.L.S. approach to runway 22 at Newark, although the fan marker and range station on the I.L.S. centreline should have been passed at not less than 1,000ft and 800ft. The F.A.A.'s action may have been taken as a result of the reported remark by the injured second pilot that some difficulty was experienced in synchronizing the readings of the three altimeters in the cockpit during the minute or so before striking the water.

The Agency say that they are not implying that the Electra's altimeters were at fault, and the C.A.B.'s inspectors are continuing to investigate all other possible causes of the accident. What is particularly interesting, in view of the experimental work now being undertaken in this country, is that Electras in American and Eastern service are equipped with single-pointer altimeters incorporating drum-type indication of ft × 1,000 (see right) which form part of the Kollsman Integrated Instrument System for air-data sensing. Although the altimeters are pressure-actuated, their movement is servo-transmitted and embodies data obtained from an angle of attack sensor and a Machmeter and corrections for calibration errors. Failure of the servo mechanism theoretically causes the instrument to revert to the accuracy standard of a straight pressure instrument and Kollsman claim that a standby is not required.

The A.R.B., as reported last week, are urging replacement of three-point presentation, not necessarily coupled with servo operation. The F.A.A.—temporarily at least—are demanding reversion to direct reading. Neither body is satisfied that altimeter presentation is yet satisfactorily unambiguous.

Footnote: In the February issue of *The Log*, the B.A.L.P.A. journal, an article ("Fool's Paradise") by Capt. S. J. L. Key suggests that three accidents in 12 months have "aroused suspicions" about modern altimeters: these were the B.O.A.C. Britannia 312 accident at Hurn; the C.A.A. Viscount 748 accident at Benina; and the B.E.A. Viscount 806 accident at Prestwick.

The dial of the Kollsman single-pointer altimeter

1958 ATLANTIC SWELL

PASSENGERS carried by I.A.T.A. airlines between Europe and North America in 1958 numbered 1,292,166—26.8 per cent more than in 1957. Of these, 1,193,213—23.2 per cent more than the previous year—were carried on scheduled flights.

A breakdown of passenger traffic between the various classes of service shows that more than half was economy-class—even though this service was not introduced until April 1, 1958. The precise breakdown is: 662,634 economy; 274,889 tourist; 255,690 first class. Passenger load factors were, respectively, 63, 61, 56.6 per cent and—though I.A.T.A. did not record this historic event in their announcement—1958 was the first year in which more passengers crossed the Atlantic by air than by sea.

Another airmark was passed in 1958: it was the first year in which scheduled air passengers exceeded 1 million.

For the record, transatlantic cargo carried during 1958 increased by 20 per cent to 25,014,771 kg; and mail increased by 16.4 per cent to 10,830,404. All in all, considering that business in 1958 suffered seriously from the American recession—the effects of which lasted until the summer—the 17 I.A.T.A. North Atlantic operators did well, though their total load factor was 61.1 per cent as compared with 66.7 per cent in 1957.

BREVITIES

The 14th I.F.A.L.P.A. annual conference will take place in Helsinki from March 10-17. Among the items on the agenda are flight-time limitations; crew complement; I.C.A.O. airworthiness committee discussions; flight-deck design; navigation aids; and Italian A.T.C. deficiencies.

* * *

Mr. L. J. Dunnett, C.B., C.M.G., has been appointed Permanent Secretary to the M.T.C.A. He succeeds Sir Gilmour Jenkins, who retires on March 31.

* * *

The public inquiry into the Viking accident which occurred at Southall on September 2 will open at Holborn Town Hall, London, on March 16. At the inquest, it will be recalled, the jury returned an open verdict on the seven people who were killed.

* * *

B.E.A. announce the appointment of Mr. P. C. Pinfield as assistant traffic manager. He joined B.E.A. in 1946, his most recent responsibility being passenger and cargo handling at L.A.P., West London Air Terminal and Gatwick.

* * *

B.O.A.C. and their associates W.A.A.C. and Ghana Airways will introduce Britannias on to services to West Africa (Kano, Lagos and Accra) as from April. Britannia 102s will replace the Stratocruisers at present in use.

* * *

Alitalia announce that their new transatlantic services from London will begin on June 1, with DC-7Cs operating thrice weekly. The daily non-stop service between London and Rome—the first such service by the Italian airline—will be operated with DC-6Bs.

Overhaul life of the Britannia's de Havilland propellers has now been raised to 2,100 hr.

* * *

The British Petroleum Company were hosts at Londonderry House on February 12 at a reception for members of B.I.A.T.A.

* * *

French domestic air fares were due to be increased by up to 20 per cent on February 18.

* * *

Talks between the aeronautical authorities of the U.K. and the Scandinavian countries concluded in London on February 11 with "satisfactory understandings" about North Atlantic services.

* * *

B.O.A.C. Associated Companies have announced that Sir Duncan Cumming has relinquished his appointment as managing director, but remains on the Board. Mr. John Linstead has been appointed to the new post of general manager.

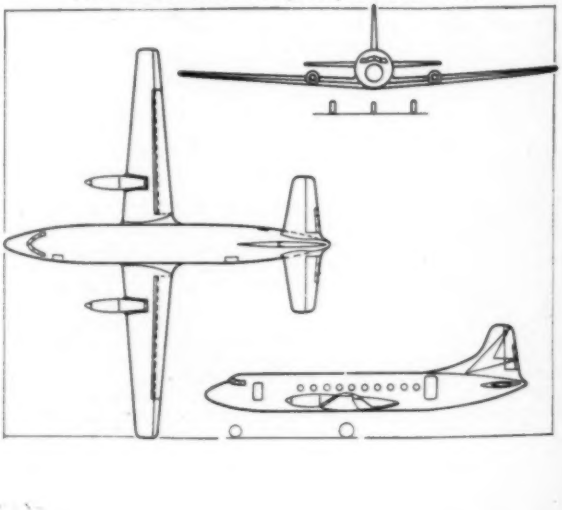
* * *

Preliminary 1958 traffic results by U.K. airlines show a six per cent increase over 1957. A total of 340m l.t.m. was carried. Load factor dropped from 63 to 59 per cent. Average rate of increase in 1955-57 was 16 per cent.

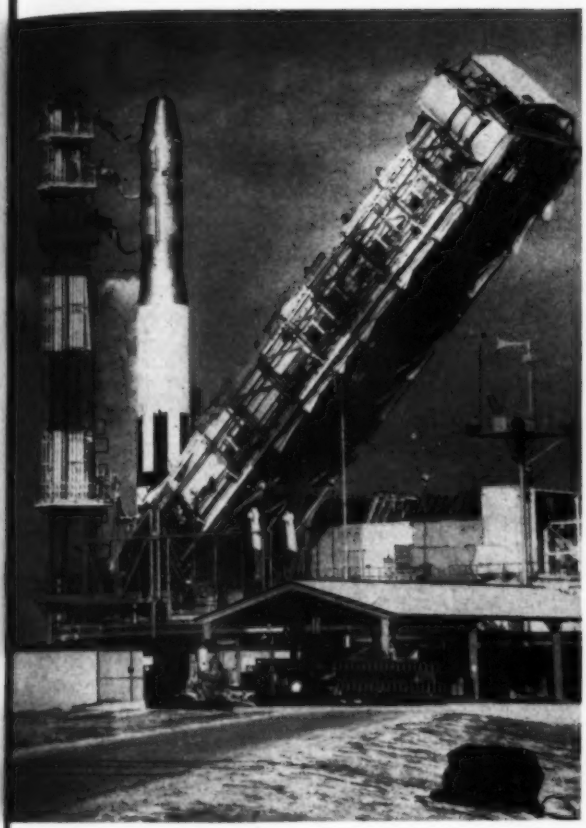
* * *

Among the topics to be discussed at the twelfth I.A.T.A. technical conference (Hotel Claremont, Berkeley, Calif, May 4 to 14) will be fuel filtration, heating and measurement; altimeter static errors; engine water- and coolant-injection; vibration indicators; flight recorders; horizons; and take-off monitors.

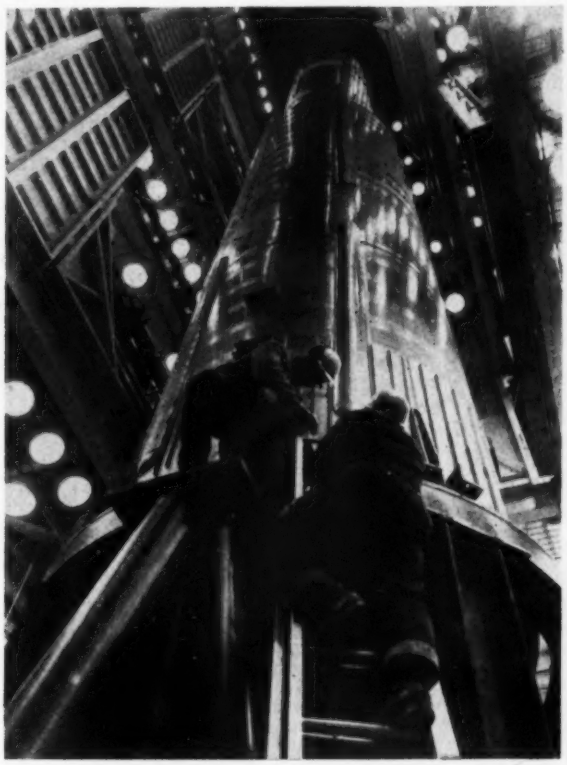
Here is an up-to-date drawing of Japan's YS-11, a Rolls-Royce Dart-powered, 60/70-seat airliner which is to be built by a Japanese industrial consortium ***(see p. 231, last week's issue)***



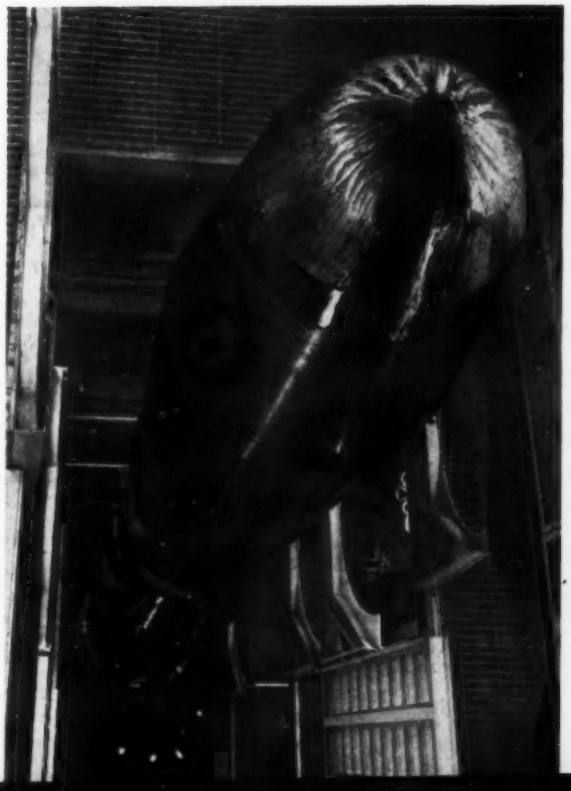
Missiles and Spaceflight



On the left is seen an XSM-68 Titan on the pad at Cape Canaveral. The umbilical connections to the second stage are very prominent and the layer of frost and gaseous efflux indicate that the liquid oxygen tankage of the first stage is filled. The oblique assembly is the 100ft erector. Below are striking views of an XSM-68 in the Denver plant



TITAN: NEW ANGLES ON A NEW ICBM



LAST week we recorded the first successful flight by the Titan, the second intercontinental ballistic missile of the U.S.A.F. Strategic Air Command. As we then emphasized, Titan has been designed to supplement, rather than to replace, the original ICBM, the SM-65 Atlas. In the words of the Secretary of the Air Force, "Titan backs up Atlas; although its schedule is a year behind Atlas, its design is more advanced."

Now that Titan has at last got off the pad it is permissible to publish photographs of much better quality than any which have hitherto been available. Those reproduced here depict XSM-68 Titan test vehicles in the factory of the prime contractor (the Denver Division of The Martin Company), packed for the air-lift to the Air Force Missile Test Center at Cape Canaveral and mounted on the pad at the latter location.

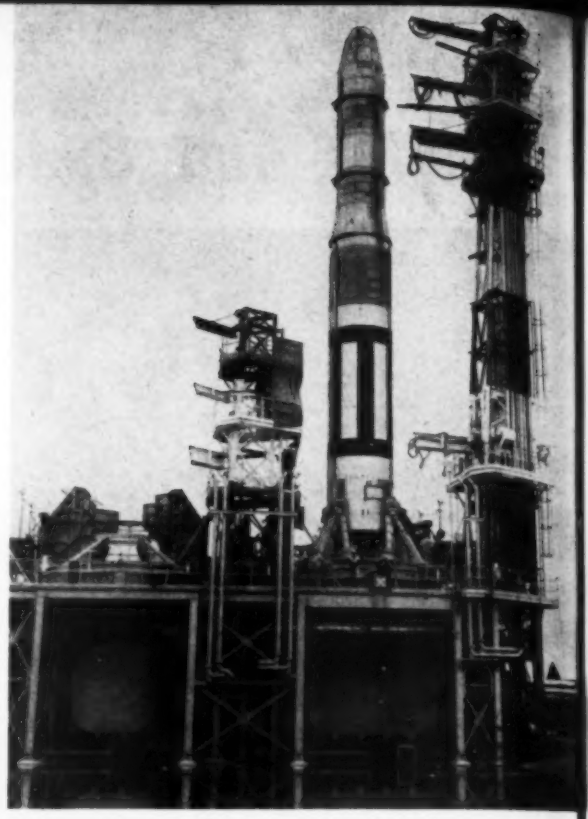
Unlike Atlas, Titan is made chiefly of aluminium alloy and is a true two-stage weapon. The first stage has a diameter of some 9ft 7in and a length of 52ft. Almost the entire interior is occupied by propellants. Integral tanks are provided for liquid oxygen and RP-1 fuel, and it is noteworthy that—unlike the layout in some liquid-oxygen vehicles—the tank for the lox is above that for the fuel. These propellants are pumped down to feed the first-stage engine, which is an Aerojet-General XLR-87-AJ-1 with twin gimbal-mounted chambers each rated at 150,000 lb. The entire first stage forms a giant booster package, discarded after the burn-out point. [*contd. overleaf*

Missiles and Spaceflight . . .

On top of it is mounted the second stage, which is some 40ft in length and 5ft 10in in diameter. About 70 per cent of the interior is integral tankage for lox and RP-1; these fluids are fed down to the Aerojet-General XLR-91-AJ-1 second-stage engine, the single gimbal-mounted chamber of which is much larger than its 60,000 lb rating might suggest (since it is fired only after the rocket has climbed out of the atmosphere and is therefore designed to an expansion ratio appropriate to flight in space). Above the tankage is the guidance section, and the entire 92ft missile is capped by its big warhead—with a maximum yield reported to be as high as 20 MT—under a blunt Avco nose-cone.

As might be expected, the largest Titan contract is that for the prime contractor; Martin Denver have been awarded a letter-contract for $384m to cover design, fabrication and testing. As already noted, Aerojet-General, at Sacramento and Azusa, are responsible for propulsion; guidance comprises pure-inertial equipment by the Arma Division of American Bosch, at Garden City, N.J., and radio-inertial equipment by Bell Telephone Laboratories, Whippany, N.J., and Remington Rand, at St. Paul, Minn. The Avco nose-cone work is centred at Lawrence, Mass.

Apart from being slightly more efficient than Atlas—a natural result of its later conception—Titan is intended for a rather different rôle. It is intended to conduct the primary deterrent task



Above can be seen the Cape Canaveral stands for the second stage (unoccupied, left) and the complete missile (occupied, right). The exhaust channels are water-cooled. In the left-hand photograph is the first stage prepared for air-lifting from Denver to Cape Canaveral

of hitting first-class objectives, with its huge warhead, while at the same time remaining relatively well protected in underground emplacements. Last September, Lt-Gen. S. E. Anderson, commander of the Air Research and Development Command, said: "In a future war, the Air Force would launch its Titan ICBMs at hard targets (those buried or well protected) and use its Minuteman ICBM against more exposed objectives." Last November a $29.3m contract was awarded to the American Machine and Foundry Company for the design and development of the Titan underground launching system. A.M.F.'s Greenwich (Conn.) Engineering Division had previously been working for some months as the associate contractor responsible for the Titan launcher system.

At present Titan is regarded as likely to prove the most important single weapon in the American armoury, pending the advent of the more flexible Minuteman system. Cost is likely to prove one of its most embarrassing handicaps, and each complete Titan base is estimated to represent an expenditure of over $100m. Plans for the construction of the first hard Titan base were announced last summer by Maj-Gen. David Wade, commander of S.A.C.'s first missile division; he said that a complete underground emplacement would be constructed on the 64,000-acre Lowry A.F.B. bombing range southeast of Denver and would be operational by 1961. By that time the missile itself should be in full production, and at the present level of expenditure the programme calls for 110 SM-68s to be operational by 1964.

EARTH SATELLITES

FUTURE Earth satellites and space probes will pose fascinating scientific and technical problems perhaps even more fundamental than those facing the physiologists and biologists in the exciting task of exploring human survival in a space environment. This was part of Mr. W. H. Stephens' conclusion to his Royal Aeronautical Society lecture *Earth Satellites* in London on February 12. Whether the goal was to launch an instrument payload or a manned space vehicle, Mr. Stephens said, the experience and techniques of aeronautical engineering, in all their aspects, would be an essential counterpart to the experimental skill and basic understanding of the physicist.

The paper presented by Mr. Stephens, who is Director-general, Ballistic Missiles, at the Ministry of Supply, comprised a review of satellites and space probes launched to date; a consideration of orbital characteristics, launching, propulsion, navigation and control; and an outline of the measurements possible and the results obtained from the various satellites. A short film was shown of the satellite-tracking techniques used by the Royal Aircraft Establishment, and a number of practical demonstrations illustrated other points in the lecture.

Among the scientific results listed by the lecturer were the facts that the flattening of the Earth at the poles was 250ft less than was previously supposed; the air density between 100 and 200 nautical miles was 5-10 times that previously assumed; and the discovery of the Van Allen intense radiation bands at 1,500-3,500 miles and 8,000-12,000 miles.

Opening the discussion which followed Mr. Stephens' paper, Mr. A. V. Cleaver (Rolls-Royce) emphasized that the reliability of the satellites and space probes must be improved before manned spaceflight was attempted. As one who, some years ago, had given estimates of the time-scale involved in spaceflight (which incidentally now seemed pessimistic) he was happy to see that astronautics had now become officially respectable—particularly in the quoted opinion of aircraft-industry representatives whose companies were running short of aircraft orders.

Mr. H. H. Gardner (Vickers-Armstrongs) said that there was an obvious need for pooling resources in the field of astronautics. International activity was very difficult, but was necessary. Mr. Mark Dowlen (English Electric) suggested that much useful research could be carried out relatively inexpensively by many countries—quite apart from the main U.S./Soviet space race—by means of techniques such as the Farside rocket project. Mr. A. D. Baxter (de Havilland) regretted that no British satellite had been launched to date. We should launch our own satellites, he said; we should also possess our own launching rockets, develop new fuels, and go in for nuclear propulsion.

Answering some of the points raised in the discussion, Mr. Stephens said that the first main problem to be solved was that of safe recovery, in which stability and control were critical, and that reliability was the job of the designer, not the scientist. International co-operation should be concentrated on observation and result analysis, and should not include the construction of hardware. Certain types of information could be obtained more effectively by sounding rockets than by satellites and, with intelligent design of vehicles and instrumentation, sounding-rocket research could pay enormous dividends. Concerning future plans, it would indeed be pleasant to do everything, but it was now painfully obvious that we must in fact be selective in deciding which line of research to follow. The number of unknowns should be reduced, thus achieving improved reliability.

U.S. SATELLITE EFFORT

Three separate Earth-satellite programmes under the heading "major unclassified military space activities" were described by President Eisenhower earlier this month in his first annual report to Congress on U.S. activities in aeronautics and space. In addition to the Discoverer launchings from the Pacific missile range, he listed Defense Department projects directed towards navigation and communications satellites.

During the first half of 1959 the President said, several tests were planned for a navigation satellite project aimed at developing a "precise all-weather system for determining sea or air position anywhere on Earth." The first satellite in this programme would be a battery-powered package weighing 150 lb and expected to orbit for about three months, and later versions would be larger and of longer life.

Several experimental communications satellites were to be launched this spring and summer, as a follow-up to the Score (Atlas) launching last December. So-called "fixed" satellites (remaining in a fixed position over a given point at about 26,000 miles from the Earth's centre) were planned for 1960 or 1961.

Civilian NASA work included Project Mercury (manned satellite), the X-15 programme, and the development of a single-chamber rocket engine of 1.5 million pounds' thrust and of a "clustered booster" of similar power. During 1959 NASA would launch some 40 sounding rockets; and twelve complete satellite systems were on order (some to be launched this year) and would employ Jupiter, Thor-Able and Atlas vehicles.

Reviewing the year 1958, the President listed 17 launching attempts with satellites (13), lunar probes (3) and space probes (1). Nine of these, he said, achieved "a measure of success." These were: (1) Explorer 1, January 31, still in orbit; (2) Vanguard 1, March 17, still in orbit; (3) Explorer 3, March 26, in orbit to June 27-29; (4) Explorer 4, July 26, still in orbit; (5) Thor-Able 1 lunar probe, August 17, altitude 40-70,000ft; (6) Pioneer 1 lunar probe, October 11, altitude 71,300 miles; (7) Pioneer 2 lunar probe, November 8, altitude 1,000 miles; (8) Pioneer 3 space probe, December 6, altitude 63,580 miles; and (9) Project Score (Atlas), December 18, in orbit to about January 22.

EXOTIC PROPELLANTS

The British Interplanetary Society continued its lecture series on Saturday, February 7, with a talk by Mr. F. Fitzgerald (of the Department of Chemistry of Birmingham College of Technology), on *High-Energy Propellants for Rockets*.

Mr. Fitzgerald first dealt with the chemical elements, from the point of view of obtaining the high heats of reaction and low molecular weights of the combustion products so necessary for the thermodynamic propulsion of rockets. The fuels giving the highest performance are, of course, hydrogen and the light metals, beryllium, lithium, sodium, boron, magnesium and aluminium, used with oxygen or fluorine as oxidants. From the performance aspect alone, hydrogen with either fluorine or oxygen was by far the best.

The other light elements were mostly solid at room temperature, and, although lithium and sodium might be melted and pumped in a rocket, all the others would have to be used as slurries suspended in kerosine. The metallic elements all produce oxides which are solid at room temperature, and some (such as aluminium) give oxides which solidify at rocket temperatures and stick to the walls of the rocket chamber.

Some of the hydrides of light elements are liquids or gases at room temperature, notably the hydrides of boron (the boranes) and of nitrogen (ammonia and hydrazine). The boranes, which are being developed as aircraft fuels in the U.S.A., give high performance with both oxygen and fluorine, but, although boron (as borax) is readily available, the production of pentaborane and decaborane is very expensive.

Apart from evaporation losses, liquid oxygen presents few difficulties that cannot be overcome, but liquid ozone is always liable to detonate, and cannot be used in more than a 30 per cent concentration in liquid oxygen. Liquid fluorine is now obtainable in tank car loads, but it is extremely poisonous and highly reactive with most substances.

On free radical propellants Mr. Fitzgerald said that while atomic hydrogen would give an exhaust jet with an extremely low molecular weight the production and storage of free radicals such as this were at present impossible, even at very low temperatures. The only way it seemed likely that they could be used was in conjunction with electric propulsion, the energy coming from a fission or fusion reactor.

ASTRONAUTICS INTRODUCED BY R.Ae.S.

The name of the Guided Flight Section of the Royal Aeronautical Society has been changed to the Astronautics and Guided Flight Section. On March 3 the section is holding an informal discussion devoted to *Rocket Propulsion—Liquid and Solid* at 4, Hamilton Place, at which attendance is restricted to section and graduate members.

NO WEIGHTING

U.S. investigations into the short-period effects of zero gravity on human performance and behaviour have recently included the use of a specially fitted Convair C-131B aircraft at Wright-Patterson A.F.B., Ohio. In a series of flight experiments carried out by the U.S.A.F. Aero Medical Laboratory at Wright Air Development Center, men have floated freely in a padded cabin 25ft long, 6ft high and 10ft wide in this aircraft for periods up to 15 sec. Fighter-type aircraft have previously been used for similar experiments, but the large cabin of the C-131 permits a wider variety of zero-g problems to be studied.

In the photograph below Maj-Gen. Oliver K. Niess and Col. John P. Stapp are seen during a zero-g phase of a flight in the Convair. Maj-Gen. Niess is U.S.A.F. Surgeon General; Col. Stapp is chief of the Aero Medical Laboratory at Wright Air Development Center and is also president of the American Rocket Society.

Frontal cloud formations over an Atlantic area of almost half a million square miles were photographed recently from this Project Hugo rocket, which was launched from Wallops Island, Virginia, and attained a height of 86 miles

Padded cabin and zero gravity: Maj-Gen. Oliver K. Niess (upper figure) and Col. John P. Stapp participating in a weightlessness experiment in a Convair C-131B from the Wright Air Development Center (news item above)

SERVICE AVIATION

Royal Air Forces and Naval Flying News

Changes of Command

SEVERAL important new appointments, each one consequent upon the other, were announced by Air Ministry last week.

Air Chief Marshal Sir George H. Mills, who has been AAFCE Commander since January 1956, is to be Chairman of the British Joint Services Mission in Washington and U.K. Representative on the Standing Group of the Military Committee of NATO. In this new post he succeeds Admiral Sir Michael Denny, who is relinquishing his appointment next July.

Sir George's present position is being taken over from next May by Air Chief Marshal Sir Harry Broadhurst, who has been A.O.C-in-C. Bomber Command since January 1956 and will be succeeded in that position by A. V-M. K. B. B. Cross, with the acting rank of air marshal.

A.V-M. Cross, who at 47 will be the youngest A.O.C-in-C. Bomber Command since Marshal of the R.A.F. Lord Portal was appointed at 46, has been A.O.C. No. 3 Group since January 1956 and will be succeeded there by A.V-M. M. H. Dwyer, who has recently been on a liaison visit to the U.S. (see photograph, this page, last week) since taking the 1958 I.D.C. course.

Air Staff Post

WITH the appointment of A.V-M. J. G. W. Weston to the senior directing staff of the Imperial Defence College from the beginning of next month, he has been succeeded as A.C.A.S. (Signals) from February 1 by A. Cdre. G. C. Eveleigh, with the acting rank of air vice-marshal. A.V-M. Weston had held the Air Staff signals post from 1956; his successor attended last year's I.D.C. course after a period of secondment as R.N.Z.A.F. assistant chief of air staff.

Aircrew Recruitment

ENTRIES of aircrew to the R.A.F., both on direct and short-service commissions, are still appreciably below requirements. This rather glum statistic was recorded in the White Paper on defence plan progress which the Government published last week (see also pages 237 and 240). The report went on to suggest that the shortage of recruits might partly be due to "the impression that, with the advent of the rocket, aircraft will have little part to play." This it stoutly denied, saying categorically that "there will continue to be many important operational tasks which only manned aircraft can perform."

R.A.F. Postings

APPOINTMENTS recently announced by the Air Ministry include the following:—

Air Ministry Squadron Leader D. J. Bolter, for duty in the Department of the C.A.S., with acting rank of wing commander, February 9.

Bomber Command Wing Commander J. M. Urquhart to R.A.F. Feltwell as Senior Medical Officer, January 19; Squadron Leader S. W. K. Hart to H.Q. for Provost duties, with acting rank of wing commander, February 2.

Flying Training Command Wing Commanders S. M. Bieber to H.Q. No. 23 Group, as Senior Medical Officer, January 30; and G. H. Dhenin to the R.A.F. Staff College, Bracknell, for studies, January 12.

Technical Training Command Wing Commanders J. W. McCombie to H.Q. as Group Captain Training (A), with acting rank of group captain, February 9; L. L. Flowerdew to H.Q. for technical staff duties, February 9; J. E. S. Salter to No. 1 School of Technical Training, Halton, for accounts duties, February 9; and Squadron Leader G. Strange to R.A.F. Hereford, to command the Boy Entrants Wing, with acting rank of wing commander, January 17.

Home Command Wing Commander F. H. D. Hutter to R.A.F. Hospital, Halton, as Surgical Specialist, January 1.

R.A.F. Germany (2nd T.A.F.) Wing Commander J. C. Bevan to H.Q., for technical staff duties, February 9.

Middle East Air Force Wing Commander R. E. B. Pinchard to H.Q., for administrative staff duties, February 9.

British Forces Aden Peninsula Wing Commanders J. R. Gardner to H.Q. for staff duties, February 5; and M. O. Richardson to R.A.F. Hospital Aden, to command, January 15.

Well-deserved Success

DESPITE the narrow margin of their victory (by 12 pt to 9), the R.A.F. were generally much superior to the Royal Navy in the Inter-Services game at Twickenham last Saturday. Their forwards were better organized, particularly in the set scrummages; their halves had more imagination and mobility; their backs were speedy in attack and moved up effectively in defence. Indeed the R.A.F. line was never crossed, the Navy's scores all coming from penalty goals; and had the R.A.F. not been over generous with offside and scrum infringements, and the Navy not been equipped with such an efficient place-kicker as Lt. H. J. Mainwaring (who scored all its penalty goals), the match might have been much more one-sided. As it was, the R.A.F. let their opponents get ahead after five minutes, then equalized matters with a penalty goal by F/L. G. J. A. Head, who was a tower of strength in the pack. Then came a delightful try by Welsh international Cpl. M. J. Price, only to be offset by a penalty which the R.A.F. conceded just on half-time. After the interval, too, the Air Force continued to keep its supporters' hearts in their mouths. For when P/O. B. B. Wright had dropped a beautiful goal and Cpl. Price gone over for another try, the Navy came up again to within three points with their third penalty goal. On balance, however, the R.A.F. well deserved their narrow victory.

IN BRIEF

Air Marshal Sir Raymond Hart, who was Controller of Engineering and Equipment until his recent retirement from the R.A.F., has been appointed director of the Radio Industry Council and is to take up his new duties on March 1.

* * * * *

H.M.S. *Centaur* is expected to lead Royal Navy ships visiting Lisbon on May 28, the day before the British Trade Fair opens there. A Royal Air Force band will take part in outside entertainments during the exhibition, which runs from May 29 to June 14.

RETROSPECT

From "Flight" of February 20, 1909

Flying Grounds at Fambridge: It is encouraging, to say the least of it, to be able to place before our readers this week some early particulars of a scheme that has been put on foot by one of our own countrymen with the express object of fostering the progress of flight in England . . .

The land which Mr. Pemberton Billing has secured is over 3,000 acres in extent, and lies between the Thames and the Crouch in the vicinity of South Fambridge, Essex. Flying rights up to the coast have been purchased, and there is thus available a straight course (a mile wide) of 25 miles at low tide. . . . The only stipulation which Mr. Billing desires to make with those who share the use of his property, is that they shall give evidence of a patriotic side to their work. And this they are to do by associating themselves with his general scheme, viz., that of founding the nucleus for an aerial fleet, which it is proposed to call the "Imperial Flying Squadron". It will be observed that Mr. Billing's proposals are of a very ambitious and praiseworthy nature; and that they are essentially intended to imbue the sporting side with a militant national aspect of a definite kind. As such, we hope that this "Colony of British Aerocraft" (as Mr. Billing proposes to call it) may meet with immediate success.

Fairey Fireflies of the R.A.F. Sailing Association, which has been presented with twelve of these craft by the Nuffield Trust, on the Welsh Harp at Hendon (London) last week when W.R.A.F. members were given instruction in rigging and sailing

Flying Aids

A "FLIGHT" Special Survey of Products and Developments, by C. M. Lambert

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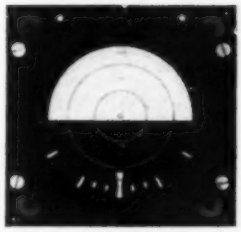


THE most pressing problem in civil air operations today is that of accommodating mounting traffic in an airways system which, in several parts of the world, is already overloaded. Not only is the number of aircraft growing, but their performance is also increasing.

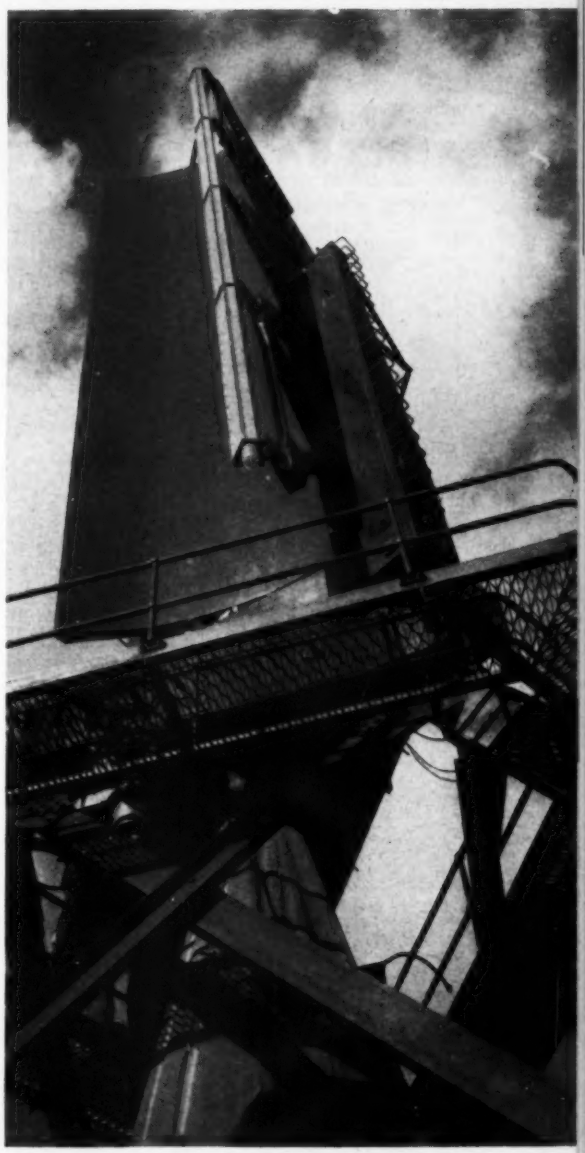
As long ago as March 1957 *Flight* stated in a leading article that two people, the pilot and the controller, must at all times know the exact position of an aircraft. Since it seems to be universally acknowledged that the pilot must have the primary control of navigation, traffic control must largely depend on communications. The days of time-consuming and uncertain voice traffic for position-reporting are numbered and the cry is for a data link. Messages can be transmitted automatically by data link, but there is a tendency to think of it as the all-powerful tool of traffic control.

Radar has achieved a similar magical significance, but it, too, has a clearly defined usefulness. The controllers themselves are asking not so much for some bright new system to do all their work for them, but for relief from those tasks which take time and energy out of proportion to the practical results achieved. They want the right information at the right time in the right presentation so that they can concentrate all their energy on the primary task of controlling traffic. Great computers and "wonder-boxes" can cause dire trouble if they fail, and they may be more difficult to fit into the overall procedure than the humble pencil and paper.

There is another requirement for the controller and to some extent for the pilot as well. They must be able to predict the situation minutes or hours ahead. Delays should not have to be concentrated in holding patterns if slight deviations applied gently throughout a phase of a flight can bring aircraft of varying performance to a given place at regular time intervals. The controller also wants to be able to assess in advance whether a conflict is likely to arise between two or more aircraft.

Any streamlining of the airways system must be matched by a corresponding increase in the acceptance rate of the airfields. For this purpose every means of reducing the time of occupation of a runway during landing and take-off must be explored. Visual guidance, control of movements on the ground and high-speed turn-offs are part of this programme, but technologically the most significant is automatic landing.

For many years "human engineering" has been applied to cockpits and instruments. It is now being applied to navigation and communications both in the air and on the ground. Perhaps the greatest difficulty is that the companies now working on complete control systems are biased towards the products they traditionally produce. They are primarily designers of radar or communications or other equipment and are only beginning to see the problem as a complete entity.



Top, the Royal Radar Establishment radar control room. Centre, the Kelvin Hughes roller-blind attitude indicator. Bottom, the Marconi S.244 height-finder aerial

FLYING AIDS . .

The traditional progress-control system, using radio and telephone and flight-progress strips stacked on special racks. This scene is in the International Aeradio training school for controllers

AIR TRAFFIC CONTROL

THIS review of present work in air traffic control gives some details of the machinery and methods now being applied to speed up the routine work of the controller. By any standards, the programmes are ambitious and expensive and apparently offer an effective answer to the problems involved. In each case a greater or lesser degree of automation is involved, as indeed it must be, but right from the start the voice of the controller himself is raised in defence of his pencil and paper. He does not want magic black boxes and lightning-fast computers unless they perform precisely the task he wants taken off his hands. Machinery can be a burden. Unfortunately there is a tendency among the manufacturers to produce integrated systems which rely too much on one of the component elements to the detriment of others, and which do more than is necessary or desirable.

A machine should only be introduced where it can be proved that it performs a task which is more effectively done automatically than manually. An elaborate message transmission system, for example, is not necessarily better than pencil and paper, especially if it requires constant monitoring and is complicated to use. Reliability and maintenance are just as critical in the control centre as they are in the air.

A complete "system" may look good on paper, but it must be compatible with neighbouring systems and it must be flexible. Stage-by-stage introduction of proven elements of what will eventually constitute a complete system is preferable. In any case, the exact requirements for automatic assistance in control centres have not yet been established, although one of the first is a common language for data input and storage. It should be possible to accommodate, with the minimum transfer processes, teleprinter, data link and simply processed flight-plan information in a form which can be stored or computed and then reproduced in readily understood or transmissible form. The main chores in the traffic control centre are, after all, assimilating, storing and reproducing information, with the secondary requirement of performing some strictly mathematical calculation based upon it.

One of the most promising progressive systems is SATCO which is being developed by Hollandse Signaal Apparaten in Holland and which is to be tried out at Schiphol during the next two years. It is basically a data processing system which is compatible with present navigation methods and aircraft performance, but which will fail safe and be capable of expansion into a complete, integrated system incorporating automatic radar and automatic communications. The heart of SATCO is a magnetic-drum store into which flight-plan information is inserted either automatically from teleprinter networks or manually by keyboards. A computer will calculate whether a conflict will arise and updated progress information is added either manually or by teleprinter. The results of computations are presented on a "tote" display, together with a synthetic radar picture giving identification, velocity and height data. The full system would include data link and advanced flight-plan information stored in the memory drum up to 12 hours before take-off.

SATCO provides separation between aircraft by arbitrary divisions of the airways into blocks 500ft deep and 3.5 n.m. long. These are either occupied or reserved and their status stored on the memory drum. New aircraft can then be cleared by the best available route, using blocks which are scheduled to become free at the appropriate time.

For the United Kingdom airways, a detailed specification for a "system" can be expected towards the end of this year. So far, a great variety of studies and experiments have been carried out to assess the exact requirements. A certain amount of equipment has been manufactured under development contracts and several independent proposals have been put forward. The M.T.C.A. itself has actively investigated the control situation and has produced a considerable quantity of experimental equipment in its own establishments.

Either by virtue of a suitable national temperament, or by good training, traffic controllers in Britain have earned a very high reputation. As a country, Britain may be late in making up its mind about a "system," but both the practical experience and the industrial backing available augur well for the final result.

The Royal Radar Establishment at Malvern, Marconi, B.T.H., Metrovick, Cossor and Decca Radar have already contributed brilliantly to military defence systems of various types. The use of radar information for defence purposes is certainly as advanced in Britain as in any other country; and there is at least some affinity between a military system and the surveillance and data handling requirements of civil traffic control. In secondary radar, Cossor have provided some solutions which were readily accepted in America. There is no shortage of technological support.

A "System" by 1963 *Ambitious A.T.C. Development in the U.S.A.*

A CHART of the United States federal airways system looks like a large spider's web crumpled up and carelessly straightened out again. Extensive knots in the New York, Chicago and south-western areas show where the routes are most closely spaced and heavily travelled and a few more or less random figures will give some idea of the problem involved in controlling the traffic. For instance, there are 26 Air Route Traffic Control Centres, each with its area of responsibility, almost 180 airfields with more than 18,000 air carrier movements per year, over 116,000 miles of teleprinter lines and 122,000 miles of telephone cable. Some 73 long-range surveillance radars have been planned for installation by the end of this year. No less than 1,320 Vortac beacons are to be set up by 1962. There are about 100,000 miles of airways. During 1956 alone there were 22 million movements at C.A.A.-controlled airfields and some 25 million position reports were made by aircraft. Every day something over 200,000 people fly through U.S. air space.

Thirty years ago there were 2,041 miles of airways in the Federal Airways System, marked for night-flying by revolving light beacons. When traffic control was instituted in July 1936 there were ten traffic controllers stationed at Newark, Chicago and Cleveland. In 1956, more than 9,500 people were engaged on this work in 500 different places. The potential growth of air traffic is illustrated by the fact that, during 1965, 33,000,000 position reports and 1,100,000 instrument approaches are expected.

Some years ago the President set up a special body called the Office of Aviation Facilities Planning headed by Edward P. Curtis, appointed as a special assistant. Subsequent investigations resulted in what has come to be known as the Curtis report. Following its recommendations the Airways Modernization Board was formed within the Civil Aeronautics Administration on August 14, 1957, and another administrative upheaval produced the Federal Aviation Agency which replaced the C.A.A. on January 1 this year. The A.M.B. was, as a consequence, transformed into the Bureau of Research and Development on November 1, last year.

The Curtis report made detailed recommendations for the improvement and expansion of the whole American airways and airfield system and A.M.B. very rapidly established a three-phase programme to put these recommendations into practice. Phase 1 required immediate steps to augment and improve the current plans of the C.A.A. Phase 2 required immediate establishment and execution of a unified, modern research and development

programme aimed principally at early application of existing scientific technology. Phase 3, which is more futuristic, involves the establishment of a permanent programme of continuing modernization of the nation's aviation facilities.

The effective result of this directive has been a huge five-year plan to run from January 1, 1958, to the same date in 1963 during which a tremendous research and installation programme is to be directed towards establishing "what will hereinafter be referred to as the 'System.'" And this is a system on the grand scale! During the relatively short 14-month existence of A.M.B. no less than 306 projects and tasks have already been established and contracts worth $21,000,000 have been placed. Congress appropriated $31.5 million for the current financial year and a similar sum can be expected for "fiscal 1960."

Government agencies, private and commercial research organizations and a great number of companies have been brought into the programme to "develop, modify, test and evaluate systems, procedures, facilities and devices, as well as define the performance characteristics thereof; to meet the needs of safe and efficient navigation and traffic control of all civil and military aviation except for those needs of military agencies which are peculiar to air warfare and primarily of military concern; and select such systems, procedures, facilities and devices as will best serve such needs and will promote maximum co-ordination of air traffic control and air defense systems." It should be remembered that military aircraft flying airways account for a significant portion of the airways traffic and that large groups of aircraft or single intercepters are at any time liable to cut diagonally across crowded airway systems at short notice.

The rough edge of the common system concept has already been felt by the introduction of Vortac as a joint standard, but the extent to which civil/military standardization is to be implemented is considerably wider than might at first appear. When the data processing central goes into service, all the flight-plan information it derives will be fed into Sage centres to assist Air Defense Command in identifying aircraft. In a number of cases, military surveillance radar information is passed to civil traffic control centres by micro-wave link, or civil operators work alongside military personnel. There is also a considerable number of joint-user airfields at which tower and approach-control facilities are jointly operated. Airways flying by military aircraft is in fact very common and this requirement is reflected both in the equipment the average military aircraft carries and in the type of instrument-flight training the pilots receive. Within Air Defense Command, the Air Defense Systems Integration Division is responsible for planning with the Bureau of Research and Development the adjustment of military and civil area boundaries with the object of setting up Air Route Traffic Control Centres and Air Defense Centres in close proximity. Eleven ARTCCs are to be moved during this financial year and a further 14 next year.

The Bureau of Research and Development has four directorates respectively responsible for operational analysis, systems analysis, systems experimentation and development, their tasks being distributed within the three phases laid down by the Curtis report. The directorate of development is primarily intended to cover those long-term projects which will eventually be incorporated in the system and includes such studies as collision avoidance systems, the use of various types of direction finding, height finding, 2-D, 3-D and coloured radar presentations and a large number of other projects. Basic research is involved, whereas the other directorates are working on programmes which must form part of a complete semi-automatic traffic-control system to be installed in the New York area by 1963. All work is divided under the headings of systems research, data acquisition, navigation, communications, data processing display, airports and weather. The broad description of the work involved fills well over 100 pages of the latest Program and Progress Report issued last November by the Federal Aviation Agency.

The first year has been devoted to producing an "experimental model of a significant segment of the improved system." Between January 1959 and July 1960 practical testing and modification will be carried out, mostly at the new experimental centre. Live trials are to begin in January 1960 and elements of the new system are to be progressively phased in to the actual operational organization by July 1961. Between January 1961 and January 1963 the complete system should be set up in actual operation and production equipment should become available.

Operational analysis includes a complete survey of traffic and the ways in which it has been delayed in all the main airways areas. The characteristics of transport aircraft, human factors, training requirements, staffing levels, weather facilities and factors and a host of other topics are also covered. Systems analysis involves the same kind of investigation of more specific projects, development of methods of simulation and investigation of methods of integrating military and civil requirements.

One of the more controversial steps has been the establishment of the new National Aviation Facilities Experimental Center at the former Pomona Naval Air Station at Atlantic City, N.J., right in the heart of a high-density traffic area. The C.A.A. Technical Development Center at Indianapolis is to be closed down. Atlantic City was, however, deliberately chosen because it was a good area for experiments with heavy traffic and because it was close to the first Sage centre set up at Kingston, N.Y. A fighter squadron of the New Jersey Air National Guard has also moved into Atlantic City and a complete set of equipment for all-weather operations and servicing and modification of aircraft is being provided to support laboratory work. As part of the collision-avoidance effort, a Beech C-18, a Skymaster, a Packet and a C-131 Samaritan have been treated with different types of fluorescent paint. An F9F-8T Cougar, a Tri-Pacer and an Aero Commander are also available, and the Constellation is being fitted out as an airborne laboratory for equipment testing.

Despite the fact that Vortac is established *de jure* as the joint civil/military navigation aid, investigation of other systems such as Loran C and the French Radio Web have been called for, while Decca Navigator is being evaluated under a separate programme as a purely helicopter aid in the New York area by New York Airways. Their Vertol 44Bs have been fitted with receivers and a Bell H-13H carries Decca and other special gear. The result of six months' operation will be analysed by another company. The Program and Progress Report gives the impression that Vortac is not by any means considered as the final navigation aid, or even as the only element of the immediate system.

The keystone of the whole new System is the Data Processing and Display Central, for the design of which General Precision Laboratories Inc. received contracts worth $8.2 million last February and June. One is for the en route portion of a system

A section of the Air Route Traffic Control Center at Indianapolis, with flight-progress racks, information boards and a Raytheon Flight Tracker radar console in the centre

FLYING AIDS . . .

to be installed, after testing, at Idlewild during 1960 and the other is for an analogous terminal/transition portion. Several sectors of the Air Route Traffic Control Center at New York International are to be moved to Atlantic City to take part in the "live" trials and Aircraft Armaments, Inc., are to supply an ambitious simulator. The G.P.L. contract was obtained after submission of 14 other bids by a total of 31 companies, including Sperry Rand and International Business Machines. Allen B. Dumont laboratories are converting an existing building at NAFEC into an extensive laboratory to house the system and its simulator. Equipment is to be installed this spring and trials will begin during the summer.

Last June, Radio Corporation of America received a contract worth $1,400,939, for the development of another key item in the traffic control system, namely, the Automatic Ground-Air-Ground Communication System (AGACS) which is a data link for either V.H.F. or U.H.F. frequencies.

Prototype equipment is to be delivered by next July to allow evaluation and completion of testing by the end of 1961. After that, AGACS will be installed as part of the System in New York. The data link will be compatible with existing communications equipment and a detailed study of amplitude modulation techniques, identification coding and recognition circuitry is now being made by R.C.A. Special airborne data displays for link information sent from the ground are to be developed and a Phase III version using more advanced principles is to be begun in 1960.

AGACS will also be integrated with "experimental navigation subsystems made up of ground and airborne components in different degrees of sophistication" intended to provide a form of area-coverage and, thereby, track freedom. Doppler, simplified inertial systems and dead-reckoning equipment in combination with ground aids are envisaged.

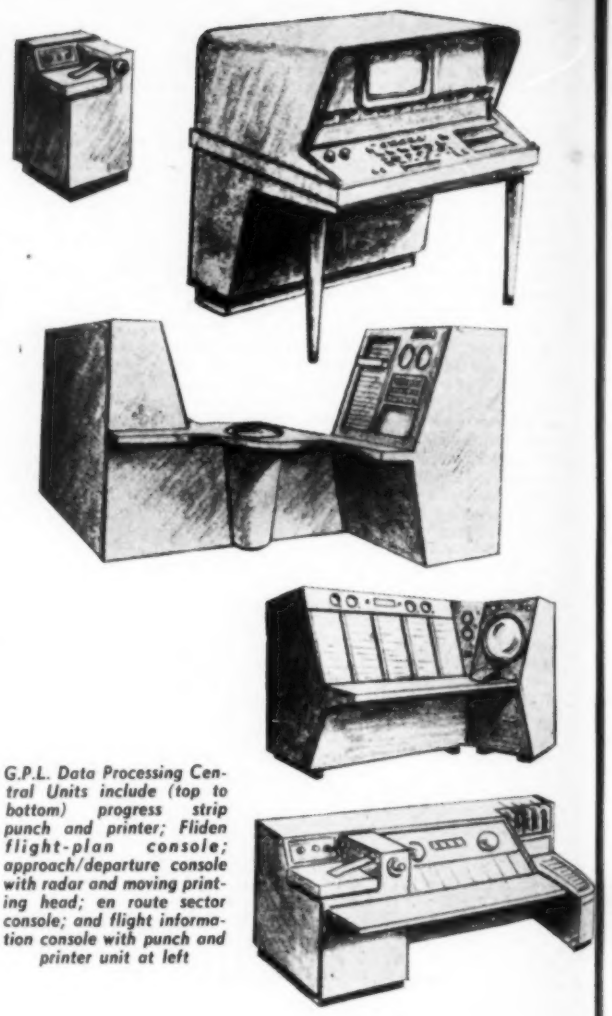
The Technical Development Center at Indianapolis was already working with a number of different methods of entering and displaying information for A.T.C. centres and much of this is to be continued and, if possible, incorporated in the G.P.L. Data Processing Central. The equipment includes the Stromberg Carlson Charactron radar display, a Sage console, electro-mechanical display boards, magnetic-drum stores, scan conversion equipment and the UNIVAC file computer. The scan conversion system was originally adapted by Intercontinental Electronics Corp., from a French system for converting a radar presentation electronically into a TV picture which could be viewed in daylight conditions. A memory function is incorporated so that targets can be shown with trailing echoes to indicate their course. Some 20 of these units have been ordered, nine of them costing $1,632,638. A further 39 scan conversion units have been ordered from Admiral Corp., of Chicago, for $5,729,116. These will be able to retain a radar echo on the screen for any time up to 30 minutes and will also show a trailing echo to indicate course. They are to be delivered during the next nine months and will be installed in existing ARTCCs.

Raytheon is supplying about a score of the 50 or so surveillance radars which will virtually blanket the airways. Another contract worth $1,786,124 has been placed with Airborne Instruments Laboratory for ten Airport Surface Detection Equipment radars which will transmit at 24,000 Mc/s with a beam-width of 0.25 deg from an aerial housed within a fabric "blister." These contracts represent but a fraction of the equipment which has been ordered, but which is not specifically related to the System. The general impression is of bewildering profusion of more or less overlapping research and production programmes which nevertheless offer an excellent chance of beating the air traffic control and navigation problem into submission.

As jet airliners begin to operate over the United States in increasing numbers, special measures are being applied to control them at heights above 24,000ft. Joint civil/military teams at defence radar stations are providing an advisory and vectoring service on the trans-Atlantic routes out of New York and along the two VOR/Vortac airways from New York to Miami. This service will be expanded as jet airliner flights are extended to new centres.

As noted above, the main hope for a co-ordinated and coherent control system in each ARTCC is based on the Data Processing Central now being developed by General Precision Laboratories. In tackling the task G.P.L. had to consider the thorny problem of combining control of heavy routine traffic with sudden peaks when, for example, a complete carrier group left its ship and flew to a shore base located within the high-density area. In addition, scrambles by intercepters through the airways had to be allowed for.

The Central is being designed for semi-automatic operation so that the human controller remains as the key decision-making agent while the major part of the routine of information handling and presentation is done for him by machines. But the human operator is also to be able to monitor the processing of information at any point in the machine routine. A detailed survey of the human factors involved, the type of information required for control, layout of consoles, manpower requirements and training



G.P.L. Data Processing Central Units include (top to bottom) progress strip punch and printer; Fliden flight-plan console; approach/departure console with radar and moving printing head; en route sector console; and flight information console with punch and printer unit at left

of personnel for both the System and the simulator is being carried out under a $135,494 contract by Courtney and Co., of Philadelphia.

The Central is based on the use of existing navigation aids and radar, but can be expanded to make use of new systems and methods. Flight plans originating within the ARTCC or a neighbouring sector are inserted into the system through special machinery which produces flight progress strips which are both printed and punched. The pattern of punched holes allows the flight plans to be withdrawn from a store when required. A computer is applied to calculating whether a conflict between two or more aircraft is likely to occur at some future time and such a conflict is positively indicated to the human controller and permanently recorded at the appropriate console. The hand writing of progress strips or their manual transfer from one place to another is entirely eliminated. The appropriate consoles are fitted with special moving printing heads which print progress information on racks.

Radar or progress-control consoles are specially designed for each phase of traffic control from the circuit to en route stages. When an aircraft takes off, its flight plan has already been recorded on a printed and punched strip and the information is passed to the transition console or to the appropriate route sector. Both airfield surface radar and precision approach radar are incorporated in the overall system.

A supervisor in the Data Processing Central is provided with an overall picture of the number of aircraft headed for each airport in his sector and the number which can be expected to enter his sector in the near future. He can match this information against the acceptance rate forecast for each airport for one, two, three and four hours in the future, so that any holding can be initiated early in a flight with the minimum delay to aircraft. Path stretching is extensively employed, with a system of booked landing times and progress checking. The supervisor can also transmit delaying instructions by keyboard to neighbouring centres when

incoming traffic threatens to overwhelm his own particular area.

The central element of the storage and computing system, known as the data processor is a transistorized digital computer combined with a large-capacity magnetic-drum storage system. It is designed to allow simultaneous operation of the computing elements, the drum file system and a flexible input-output buffer system, so that information may be put into the computer or extracted from the file drums without interrupting the main computation process. Some 4,000 eight-character words may be retained in the internal core memory and the computer uses the basic 60-character alpha-numeric character structure with a seventh bit for parity checking. All arithmetical operations and information transfer are checked in this way. The drum file system consists of up to ten (or more if required) drums each duplicated to prevent loss of information after a failure and each capable of accommodating 2,000 64-character records. Fixed- or variable-key selection is available for extracting records.

The high-speed buffer drum and its associated circuitry can accept data from input-output teletype, typewriters, keyboards, flight progress strip printer-punchers, analog-to-digital converters and other sources. It can accommodate 210 64-character blocks derived from combinations of the sources listed above and input and output rates of 200 characters per second are possible.

When the Central is installed in the New York area it will be able to process 400 flight plans per hour and store 2,000. It will print and process 1,600 up-to-date flight progress strips per hour. Each hour 60 aircraft will be led down to each active runway and another 60 aircraft will simultaneously be monitored from each runway on to outbound courses. The capacity can be increased by adding more of the standard units as required. All traffic-control procedures so far analyzed can be performed with the Central.

This is a very ambitious programme and one which has got under way remarkably quickly. It represents a typically American approach to the problem, involving the maximum use of machinery and computation. By relieving the human controller of all but the monitoring and decision-making function, it undoubtedly speeds up the routine work of conventional traffic control and allows a measure of accurate forecasting of traffic intensity. Timing and scheduling with machine assistance are also important new control adjuncts. Such a system will make the greatest possible use of existing aids, but it will hardly be able to overcome any basic deficiencies in navigational equipment. The effectiveness of control of separation between aircraft must always depend on the accuracy with which the pilot can maintain a designated course, speed and height and upon the rapidity and accuracy with which information and instructions can be transmitted to and from the control centre.

Data Processing Central should make it possible to saturate the airways as at present constituted, provided that the data link can perform the high-speed communications task One cannot help feeling that a more flexible navigation system will, however, prove a *sine qua non* at a relatively early stage in the future.

Radar in Air Traffic Control

Data Gathering and Presentation

SURVEILLANCE radar is being increasingly applied to air traffic control and it is the purpose of this section of the review to describe its capabilities in this work. Radar offers a service which, at first sight, apparently has no limits. Synthetic display, data storage and the many other special circuits and devices provide an unrivalled flexibility which raises visions of G.C.A.-like control of aircraft crowding along an airway with the minimum separations, all controlled by a man who has a completely reliable and fully informative picture of the situation before him.

What, then, if the radar breaks down or is swamped? How many pilots are prepared to be vectored by radio commands without themselves having a clear picture of their situation? Will the communications frequency stand up to the voice traffic required in issuing and acknowledging orders?

It is probably true to say that the real function of radar in air traffic control is not yet clearly defined. In Britain its use in the future might be relatively limited as compared with the U.S.A., where radar looks like becoming a major and even a dominant element in air traffic control.

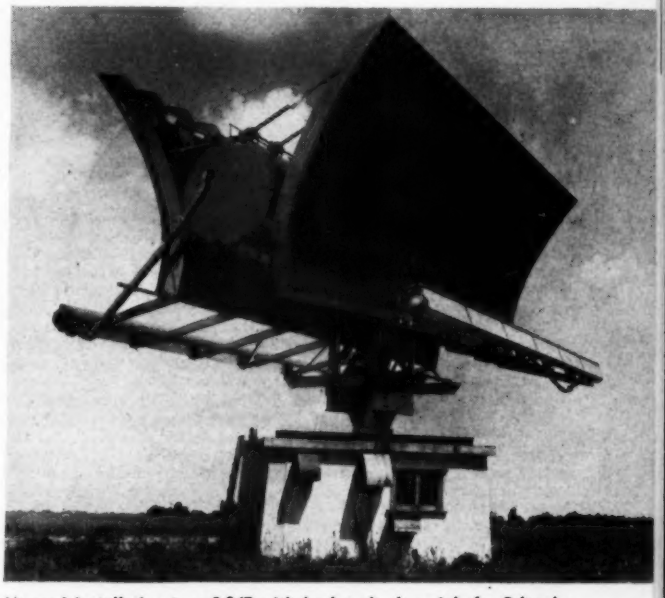
One of the first considerations in choosing a radar for air traffic control use is wavelength, the choice lying broadly in the bands of 3 cm (10,000 Mc/s), 6 cm (5,000 Mc/s), 10 cm (3,000 Mc/s), 23 cm (1,800 Mc/s), 50 cm (600 Mc/s) and 150 cm (200 Mc/s). Each of these bands offers certain attractions, but it is generally true to say that although the shorter wavelengths allow very much higher discrimination in the radar picture which they produce they are more sensitive to interference from rain, snow and hail and that it is more difficult to achieve the high powers and therefore the longer ranges. For the shortest wavelengths, waveguides are small and internal arcing must be avoided. Arcing and heat dissipation in valves also present problems. Pressurization of waveguides and extensive cooling systems needed at the higher powers aggravate maintenance problems in an equipment which must be essentially designed for unattended operation.

The longer wavebands have considerable attractions, which are enumerated below, but the most important and the most wayward judge is the user himself, namely the air traffic controller. Unfortunately he tends to be as individualistic as a pilot and has often stated that he particularly wants features which are almost irreconcilable characteristics of radars in both long and short wavelengths.

Marconi's, with considerable experience in designing both civil and military radars, have now stated a distinct preference for the 50 cm wavelength for civil applications, although they still offer the full range. The following analysis of Marconi's reasoning to support the 50 cm equipment forms a good background to the type of considerations which are involved.

The reflection of radiant energy from a spherical object decreases as the fourth power of frequency and even a small increase in wavelength therefore offers considerable attenuation of unwanted reflections from rain. This is a particular advantage since the ability to see aircraft by radar is obviously much more important when weather is poor than when it is good.

When radar energy is projected from the aerial system a proportion of it strikes the earth's surface and is reflected to follow a longer path to a given point in space than the non-reflected



Marconi installation type S.247 with back-to-back aerials for S-band and L-band radars. Both will be viewed with a single display tube

radiations. The direct and ground-reflected signals will at certain points be in opposite phase and therefore cancel each other out. A vertical section through the coverage pattern will show that the areas in which cancellation occurs cause deep indentations in the coverage pattern called minima which split the pattern into a series of lobes. With the shorter wavelengths these minima will be more numerous and begin at smaller angles to the horizon. Although 50 cm radiation will have minima, they will be few and shallow, and full coverage of an aircraft flying at 30,000ft will be available from the maximum range of about 140 n.m. right in to the back angle. In order to achieve good ground-reflection characteristics, a 50 cm aerial should be mounted as close to the ground as possible but, because it is large and consequently needs a sizeable pedestal, it is difficult to set it less than about 12ft above ground. High powers of the order of several megawatts, and therefore long ranges, are easier to obtain in the bands from 10 cm upwards.

It is of major importance that some form of moving target indication should be available in a surveillance radar to allow partial or complete cancellation on the cathode-ray tube of returns from ground features or rain and snow. But, although controllers

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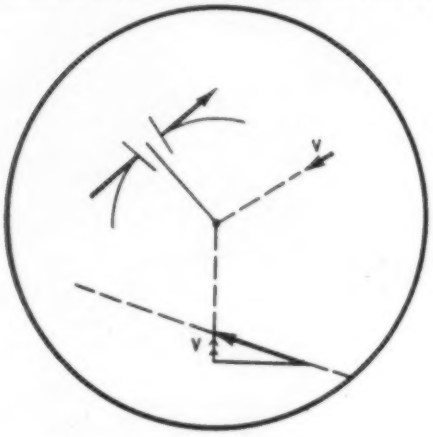
must have an uncluttered picture, they are almost unanimous in wanting to retain some indication of storms and ground features to help them in controlling traffic. It should therefore be possible to apply M.T.I. progressively and not on an on/off basis.

There are various ways of achieving M.T.I. One simple method proposed by Decca Radar Ltd. for their 10 cm, 800 kW DASR.1 equipment is Airborne Target Indication. The Decca radar employs two aerials mounted back-to-back (a concept developed by the French company, Société Nouvelle d'Electronique), one of which covers shorter ranges and greater altitudes while the other covers the longer ranges and lower altitudes with a low-looking beam. The two patterns are considerably overlapped. Clutter originating from ground features occurs at the closer ranges and these, say Decca, can be conveniently eliminated by gating the low-cover receiver to cut out returns from the shorter ranges. The resulting "dead" area, with a radius of, say, 20 miles and a maximum depth of 1,500ft, is not important in airways control work. A video blanking distribution unit allows gating to be applied at varying ranges as the aerial rotates in order to eliminate only those areas where ground clutter occurs.

Decca use a second system to suppress unwanted echoes from rain, snow and hail. Linear polarization is normally applied to the signal radiating from the aerial-feeder horn, but this can be made elliptical or circular by electronically splitting the signal and delaying the phase of one part of it. The polarization of the Decca radar can be moved from linear to circular in order to eliminate progressively the clutter from raindrops and snowflakes of varying shapes. This does, however, result in certain loss of range.

M.T.I. is an electronic means of cancelling reflections from stationary objects. In general it can be said to have two serious disadvantages. First, as an aircraft flies at right-angles to the beam of the transmitter its radar reflection will not show any movement



Above, the two conditions under which normal electronic M.T.I. will cancel an aircraft echo. At upper left the aircraft is on a tangential heading while in the other two instances the radial speed component V falls within one of the critical speeds although the actual airspeeds and headings are greatly different. Below, the transmitter, receiver and aerial turning head of the Marconi S.232 50 cm radar at R.A.E. Bedford

relative to the aerial and it will, for a short period, be cancelled as a stationary object. Second, at certain radial speeds relative to the aerial the aircraft reflection will again be cancelled. A typical group of radial components at which this will occur is 170 kt, 340 kt and 510 kt.

There are three main methods of overcoming the two disadvantages of electronic M.T.I. Firstly, the pulse recurrence frequency of the transmitter can be varied, or "jittered." Since the unwanted cancellations originate from the timing of the pulse transmissions, constant variation of this timing will virtually eliminate the critical speed and heading conditions. Secondly, Marconi have developed clutter gating by which means an electronic switch in the receiver can automatically select M.T.I. when the length of reflected pulses indicates the presence of clutter. The length of the received pulses is measured and the longer pulses reflected from stationary objects will cause the electronic switch to select M.T.I. Otherwise, raw radar is maintained. Clutter gating can be applied at specific required ranges from the aerial as well as in appropriate azimuth sectors.

A third method is pulse length discrimination by which the width of the video pulse resolved from the received signals is compared in a discriminating circuit with that of the standard transmitted pulse. When the received-pulse width is appreciably greater than standard it is attenuated and if more than double the standard value it is entirely suppressed. The heaviest clutter is thus eliminated with negligible effect on performance outside the clutter zone. Targets within the clutter area will remain visible so long as the clutter is not limiting. Pulse-length discrimination generally leaves a speckly area on the tube face where clutter was present, but aircraft can still be seen within it.

All three techniques could be applied to a single radar although they would generally be arranged so that clutter gating and pulse-length discrimination could be switched off when not required.

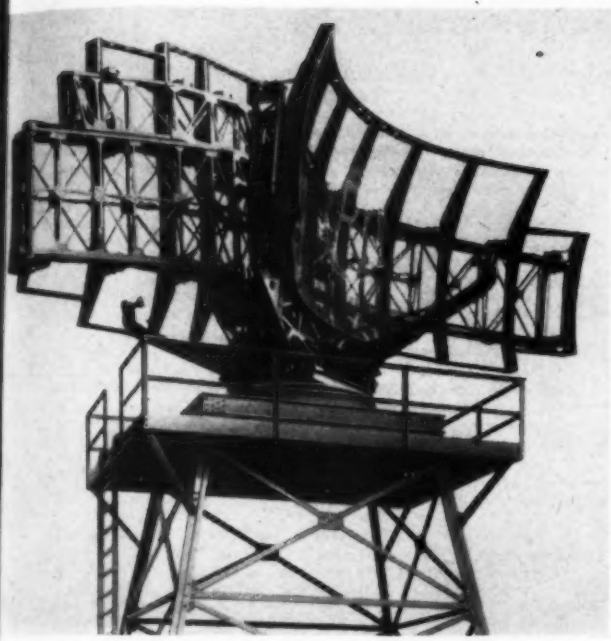
An M.T.I. circuit needs a highly stable oscillator, but the magnetrons used for the shorter wavelengths are inherently unstable in frequency. The Marconi 50 cm radar is entirely crystal-controlled using conventional techniques and the stable frequency is therefore automatically available even immediately after switching on. In magnetron-controlled radars a memory circuit may be incorporated to retain the transmitter pulse frequency during the related reception time and provide a frequency reference, but this is rather complicated.

The disadvantage of the longer wave radars is that the dimensions of the aerial are related to wavelength and must be large to achieve narrow beam-width and sufficiently high gain. An aerial width of up to 50ft is not uncommon, but such a size presents no insoluble problems of engineering and siting.

The transmitter/receivers of surveillance radars at present offered for commercial use are generally designed to run unattended for long periods and are duplicated and provided with automatic monitoring circuits and automatic change-over. The layout and installation of transmitter/receivers can be said to have reached the status of a fine art, components generally being arranged to be fully accessible from one side of the cabinets. Sub-assemblies can be exposed either on hinged frames or on telescopic runners and examined in this position while still operating. Built-in meters and oscilloscopes allow full analysis of performance during operation and starting.

The aerial reflector must be accurately formed and maintain its shape regardless of wind forces of 80 or 90 kt. Similarly, an accurate rate of rotation must be maintained and all these requirements add up to a considerable engineering problem with the larger aerial assemblies. The stabilization of tall towers on which some aerials are mounted is perhaps the most intractable problem. If, as in the case of radar height-finders, the azimuth or elevation position of the aerial is to be mechanically sensed to measure height or bearing, some form of parallelogram linkage between the aerial and its mounting may be required to avoid distortion from structural deflection.

In some cases it will be necessary or desirable to locate the radar some distance from the control centre which requires its information. Over a few hundred yards this can be achieved over land-lines, perhaps with intermediate amplifiers but, over longer distances, a microwave link can be used both for the transmission of radar information and for radar control signals. The cathode-ray tube presentation will be derived from turning information taken from the aerial head and video output from the transmitter/receiver, both being superimposed as a modulation on the microwave signal. In cases where direct line-of-sight communication between radar and centre is impossible repeater stations can be interposed. Control signals would include information on radar performance, and commands for switching the radar on or off or changing to the stand-by transmitter. A



The back-to-back aerials of the Decca Radar DASR.1 10 cm surveillance radar. They were designed and, in this particular instance, made by the French company, Société Nouvelle d'Electronique

Marconi microwave link with remote control-facilities is installed in New Zealand and a number of Collins links are being set up in the U.S.A. Decca Radar have also produced link equipment. The projected British airways surveillance system will probably also incorporate microwave link systems. Link frequencies may be allocated in the telecommunications band of 3,800 to 4,200 Mc/s, the multi-channel and television band of 6,000 to 6,400 Mc/s or the civilian and Service link band of 7,300 to 7,600 Mc/s.

The Use of Radar Information

In the normal air traffic control procedure, the controllers obtain information on the position, progress and intentions of an aircraft by means of telephone, teleprinter and radio communications. The information is noted on flight progress strips which are inserted in holders and shifted from point to point on special racks to form an approximate picture of the traffic pattern over a particular route or sector. It is therefore largely up to the controller to visualize the situation in the air, although the actual situation as opposed to reported location of aircraft may be affected by navigational accuracy, communications time-lag and adherence of the pilot to procedures.

The separation required between aircraft in a particular area is accordingly based on a knowledge of the navigational accuracy and degree of control which can be achieved. Over the North Atlantic, for instance, separations of 30 min along track and 120 miles across track are required because the facilities now generally used do not permit more accurate control either from the ground or in the air. Dectra and Doppler can considerably improve North Atlantic navigation. Much closer separations apply on airways over Europe and the U.S.A.

In the British Southern Air Traffic Control Centre at London Airport, surveillance radar was adopted some years ago as a means of locating aircraft in the London terminal area and of guiding them from stacks to the runway centreline. Although it provided a raw radar presentation which had to be viewed by an operator isolated in a darkened cubicle, the radar information was particularly useful in establishing the positions of aircraft in relation to each other. The actual radar used was an American MEW S-band unit with a range of something over 100 miles.

In due course M.T.C.A. sponsored development of the Cossor ACR.6 airfield control radar and later a 50 cm Marconi S.232 was obtained. The ACR.6 was used for procedural control in guiding aircraft from the Watford and Epsom stacks on to the I.L.S. centreline. The S.232 could pick up aircraft very soon after take-off and was applied to the control of outbound aircraft. The longer range MEW equipment is now being replaced by two Marconi S.14 radars, separately mounted but synchronized to rotate back-to-back. One is set to cover the high sector and the other the low. The latest equipment to be ordered for S.A.T.C.C. is a pair of Marconi S.264A 50 cm radars of 500 kW power—incidentally representing the first use of power klystrons in civil radars. The first S.264A is to be installed by June this year.

The raw radar picture is full of confusion. In addition (and this is often considered more important than the point just mentioned), the screen must be viewed in a darkened room. From the controller's point of view both these factors are of major importance. A man can only concentrate on a radar screen in a darkened room for a few hours before eye-strain begins to tell and, in any case, darkened surroundings are uncongenial. A higher level of light can be tolerated if "white minus amber" lighting is used.

Radar must be combined with information from all other sources before it achieves full usefulness, but radar and flight progress strips cannot be viewed together in either full darkness or full daylight. Many air traffic controllers consider that the first step towards making radar a really useful air traffic control tool is to render it usable in daylight. Bright displays are discussed in greater detail later in this account.

The main difficulty with raw or near-raw radar lies in identifying aircraft. Conventional D.F. is often used to assist in this, but is obviously ineffective where two or more aircraft lie on or near the same bearing. The controller can order an identifying turn, but this uses valuable communications time and may take the aircraft undesirably off course.

The ideal presentation would be in the form of a three-dimensional "goldfish bowl" in which all aircraft were clearly identified and could be seen at their actual heights. No radar at present in operation can produce a true three-dimensional picture although those using a volumetric scan are capable of presenting plan-position and height on separate tubes. But progress towards the complete three-dimensional picture is following the rather simpler technique of producing an unequivocal plan-position picture in which each aircraft indication bears a height reference.

Based to a large extent on military defence-system work, a civil aviation data handling system is being developed by Marconi, and Decca Radar are also working on civil equipment to the same end. The first elements of Marconi's system were exhibited at the S.B.A.C. display last year and their military equivalent was to some extent revealed at R.R.E. and at the Marconi test site at Rivenhall last year (*Flight* for May 2 and October 10). It is based on a store into which full information on each aircraft can be fed and from which such information can be selectively withdrawn. In this way, both flight-plan information and actual observations can be combined and computed for the progress controller.

To this end a considerable variety of additional features have been added to the normal raw radar display in order to produce as the working medium a completely synthetic picture bearing only relevant and identifiable information. A control system based on this type of surveillance radar will therefore consist of three major blocks. The first of these will be devoted to gathering information on aircraft movements from a radar presentation incorporating the various clutter-removing systems. On this it is possible to superimpose a map of the area being viewed either as a transparent engraved overlay or in the form of a video map electronically superimposed on the tube face. To produce a video map, a radial beam is set to rotate on a cathode ray tube in synchronism with the rotation of the aerial. The beam is scanned through a photographically marked glass slide and converted into video signals which are mixed with the incoming radar signals. Video map eliminates parallax errors and always remains synchronized with the radar picture when different range-settings are selected or when the display is off-centred in order to concentrate on one sector of an area. A transparent mask engraved with direction lines is often mounted over the tube face so that bearings can be read against a bearing scale round the periphery of the tube. Instantaneous automatic gain control (I.A.G.C.) is often applied to even out responses of varying strengths.

Cathode ray tube displays can be divided basically into two types, moving- and fixed-coil. The former have deflecting coils at the neck of the tube which rotate in synchronism with the aerial. They are simple to operate and offer a high degree of bearing accuracy; but only a limited amount of additional information can be incorporated in display without affecting quality. On fixed-coil displays, the fly-back or idle time of the scanning spot can be used to provide something like a dozen additional patterns and traces, which makes them most useful for traffic-control work.

As mentioned above, an aircraft can be identified in a raw radar picture either after performing some distinctive manœuvre which will make its track on the screen obvious or by taking D.F. bearings on it and deciding from these where it lies. For this purpose it is possible to superimpose directly on the radar display the bearing trace or traces produced by one of the automatic D.F. or fixing systems. The D.F. traces originate on the radar display at the geographical location of the D.F. ground stations. Finally, controls can be provided with which the origin and bearing of a movable line can be positioned anywhere on the radar screen so that additional bearing or vector information can be derived.

With the features described above it is possible to modify the raw radar to the extent of partially or wholly eliminating clutter,

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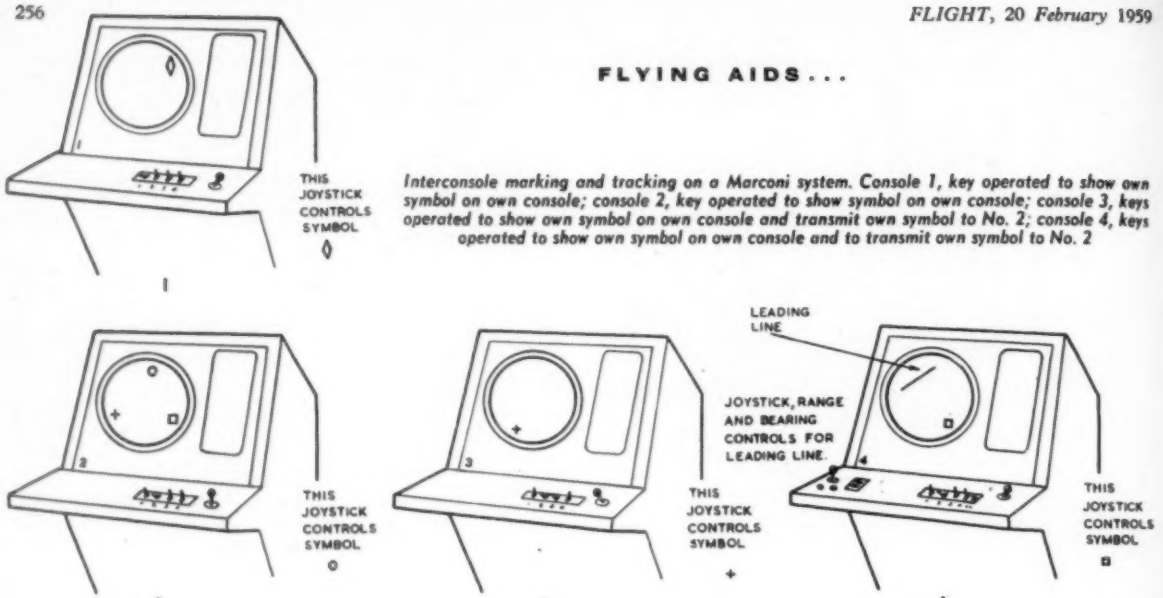


Interconsole marking and tracking on a Marconi system. Console 1, key operated to show own symbol on own console; console 2, key operated to show symbol on own console; console 3, keys operated to show own symbol on own console and transmit own symbol to No. 2; console 4, keys operated to show own symbol on own console and to transmit own symbol to No. 2

to fix the position of an aircraft with a D.F. triangulation system in relation to a map electronically incorporated in the display and to make an accurate assessment of the required track and distance to reach a given point. This affords a simple method of identifying and directing aircraft.

Such a system is already used by the Régie des Voies Aériennes in Belgium with back-projection onto a ground-glass map screen of C.R.D.F. traces (Standard Telephones and Cables PVT.1) and surveillance radar. Both fixing and directing functions must rely on the communications channel and heavy traffic might saturate the system, although this consideration applies equally to any organization depending on surveillance radar.

The identification process could be made less cumbersome and a more comprehensive picture of the situation produced by integrating flight progress information with radar surveillance. The radar picture itself can be improved by extracting velocity information from it and displaying this together with flight-plan information on another screen.

Radar will provide a continuous series of position reports from which a skilled operator can make an assessment of speed and direction of movement. The identification problem can be greatly simplified by advance warning of the arrival of an aircraft in the scanned area and by a knowledge of its intentions, whether such information is derived from the radar surveillance in a neighbouring area or from flight plans, the essence of which is featured on the flight progress strip. Radar and non-radar information can be combined in a data store.

The object is to provide all available information, without any irrelevant signals, to the executive controllers. In the Marconi system, which is typical, it is foreseen that one group of operators will identify and track aircraft and be able to transfer the resultant information into a store where information from other sources will be added. A series of symbols can therefore be superimposed on the radar screen and steered by means of a joystick control to lie over an aircraft echo. In order to allow cross-referencing between operators, the symbol and its position on the tube face can be electronically repeated on another tube so that one operator can position a symbol over an echo, press a switch and make the same symbol appear round the same echo on another screen.

The next stage is to derive velocity information from the radar display by making a symbol follow an echo across the screen. Using a fixed-coil display, there are two methods by which this can be done. Firstly, the symbol can be given a speed and direction by joystick control so that symbol and echo move along together. The velocity can be judged "by eye" so that the symbol follows the aircraft until it changes heading or speed. This kind of tracking system is called rate-aided and has been produced by Marconi, Decca Radar and Cossor. With additional equipment it is possible to lock the symbol electronically to the echo so that they will remain synchronized wherever the echo moves. This obviously has its advantages because the operator no longer has to check that rate-aided symbol and echo are staying together; but if the tracks of two echoes cross, the electronic following system will be confused and circuits to overcome this difficulty are complex. The automatic tracking system is generally called lock-follow or auto-follow.

A variety of symbols can be provided for either rate-aided or automatic following and it is estimated that a single operator can effectively supervise about a dozen different aircraft in this way. A group of operators would in practice be monitored by a supervisor who allocated targets and constantly reviewed the overall situation. From this radar information-gathering stage the tracking symbols and their velocities could be electronically transmitted to other tubes for direct use in progress control, or they could be fed into an electronic store with an identifying number. The store is in effect the second block of the overall radar control system and, in addition to receiving track data and identification numbers from the surveillance radar section, it would accept information from such sources as radar height finders, radar transponder beacons carried in aircraft, and flight-plan information derived from the conventional land-line and radio sources.

In all probability the data stores used in traffic control systems will be based on binary digital inputs. The analogue devices using voltages or uni-selectors would become uneconomical if more than 30 tracks were involved because of the bulk and cost of the mechanisms and because of difficulties in the input and output sections. About 160 "bits" of binary information are required in order to store details of route, height, course, speed, call-sign, change of height and other relevant flight-plan data. A store based on a ferrite matrix is favoured by Marconi, while magnetic drum systems are being used in the Dutch SATCO and the American Data-processing Control.

The store of the Marconi civil aviation data-handling system shown at Farnborough last year has a capacity for up to 160 tracks. Identified tracks are passed from the fixed-coil displays of the information-gathering section into the store which can automatically compute the co-ordinate velocities. Present-position information is kept up-to-date by continual rate-aided tracking. Additional information from non-radar sources may be added to the store by manipulating keyboards. Further channels could be provided for air-to-ground data-link. All the information can be extracted from the store in a form suitable for use in computers designed to assist controllers in co-ordinating traffic.

The third block in the Marconi system is the executive element of the control organization and the equipment consists of two basic displays. The first is a completely synthetic radar display on a cathode-ray tube which will present only computed information, probably orientated in a video map. Two basic variations of display can be selected by switches. The first is a so-called "tadpole" display in which a bright dot shows the position of an aircraft and a "tail" of lower brilliance indicates its speed and direction. The second is the symbol display in which the present position of an aircraft is shown by a symbol accompanied by letters, figures and signs giving the track-identification, and height represented by two figures for thousands of feet and a dot for 500ft. A "tadpole" in this case will show whether the aircraft is climbing or descending and a bar indicates whether or not the information has been derived from radar. It is obviously important that the quality of the information shown on the tube should be known.

Since all information used at this executive stage is being drawn from a store with ability to make computations, the controller can "advance" the display up to 7½ min into the future to gain an idea of what the situation will be if all aircraft maintain their present

velocities. He can also transmit a special query symbol on to the supervisor's display so that if, for example, he wants to make two aircraft fly close to each other he can ensure that particular attention is paid to tracking them in the information-gathering section.

Beside his synthetic display each controller will have a second cathode-ray tube on which, in tabular form, he can observe written information on four or more different tracks. This will provide him with necessary background information on call-sign, route, destination, present height, requested height and E.T.A. at a reporting point to enable him to make a considered decision. By dialling or depressing an appropriate key he will be able to call for information on any of the tracks at present in store. Sampling circuits can also be applied to the store so that all tracks in a given sector or at a given height band can be viewed on one of the synthetic displays (see diagram on page 258).

Automatic handling of land-line communications might be an additional requirement for a control centre. Standard Telephones and Cables have in this context produced the STRAD system which is fully electronic and capable of receiving information in telegraph code and retransmitting it on one or more telegraph channels. A routing code will ensure that messages are automatically sent to the right places, or push-button control may be applied. STRAD utilizes magnetic storage in either drum or ferrite forms and can deal with messages according to a variety of preset priorities.

The problem of identifying aircraft on radar presentations can be very considerably eased by the use of airborne transponder beacons. It is reported, in fact, that the American F.A.A. has announced that no aircraft flying above 24,000ft will receive surveillance radar service unless it carries a transponder. Aeronautical Radio Inc. laid down a transponder specification with ARINC Characteristic 532A and this was subsequently modified by I.C.A.O. and internationally standardized. The I.C.A.O. transponder is described in ARINC Characteristic 532B against which numerous complaints have been registered by American manufacturers of this type of equipment.

Nevertheless, Cossor Radar & Electronics Ltd. are now producing the Type SSR.1251 transponder to the new specification. It is a combined receiver and transmitter which replies to a suitably coded interrogation from a ground transmitter with a sequence of pulses, the number and spacing of which can be varied to produce a number of codes. In this way, identification or height information can be superimposed on the range and bearing indication derived from the related display on the ground.

An advantage of the transponder system is that the cathode ray display on the ground will show only transponder replies and none of the clutter characteristic of raw radar. In addition, because the reflected radar signal is effectively boosted, the interrogation transmitter requires only 1/300th of the power of a primary radar of equivalent range.

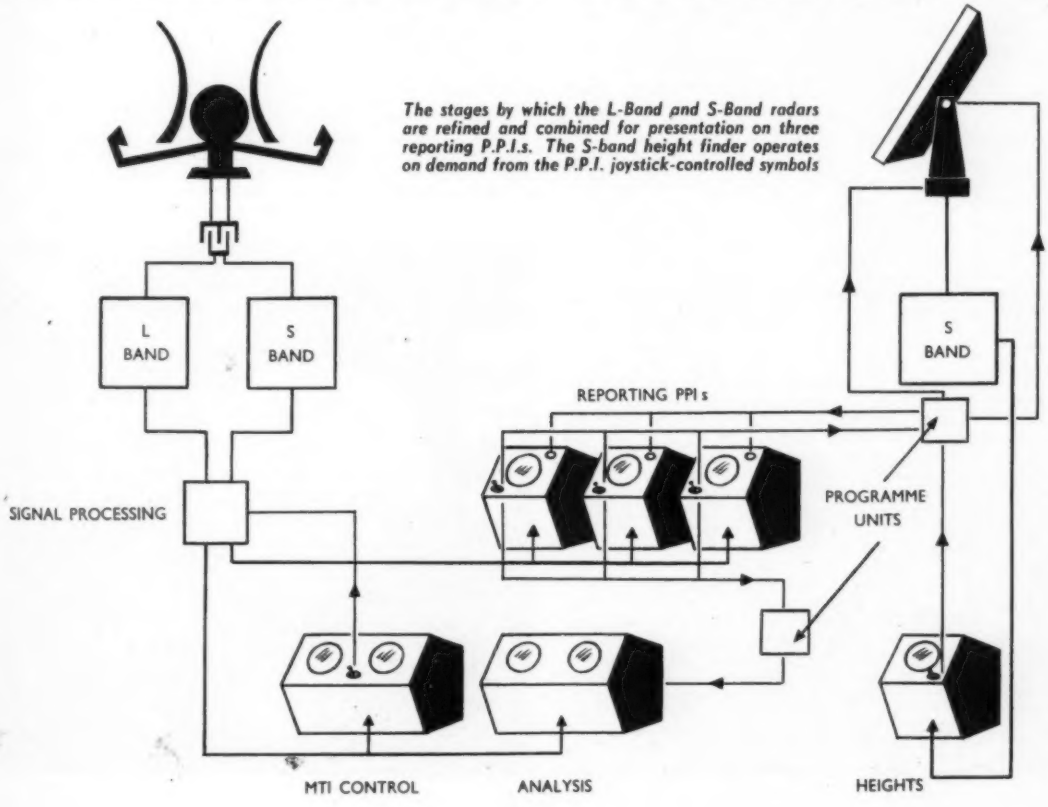
The Cossor SSR.1251 weighs 21 lb and both the ground and airborne equipment has been evaluated in Britain and America. The Cossor CRD.23 display system for use on the ground can incorporate identification markers and relative range and bearing marker. Any number of viewing units, operating independently of each other, may be installed and erected up to ten miles from the aerial. C.R.D.F. information can be displayed and a twin video mapping unit allows presentation of short-range maps with extended runway centrelines and long-range maps showing airways. The fixed coil deflection system allows incorporation of up to ten identification symbols and of rate-aided tracking. Bearings, ranges, speeds and courses can be derived from scales on the relevant controls. The symbols can either be transferred to other displays as required or passed to an electronic computer.

Reliability is Critical

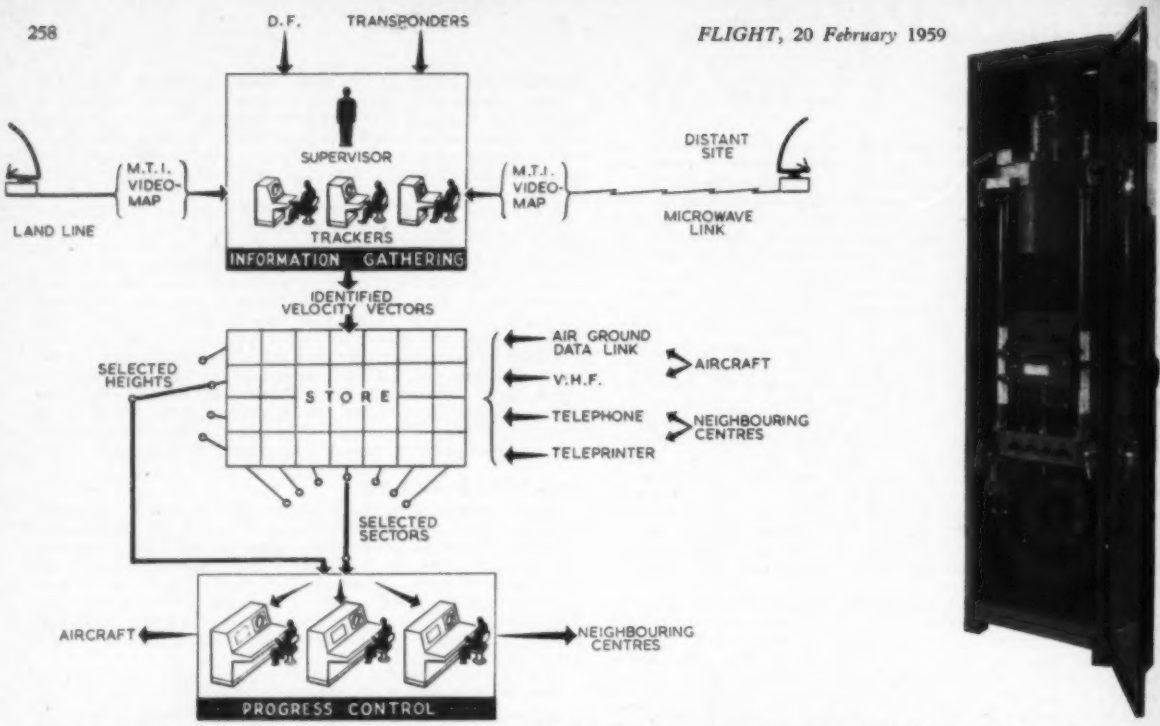
With a system of this kind it is possible to reduce separations between aircraft considerably if the store can effectively record and sift information from many sources and the human operators can efficiently perform the tracking and control functions. But what happens if the separations have been reduced to the basic minimum and the power supply to the whole control centre fails? The results are highly unpleasant to contemplate. Obviously complete reliability or a standby must be built into any system right from the start.

It is safe to say that any civil surveillance radar has duplicated transmitter/receivers with automatic changeover. Routine servicing can be carried out on one side while the other is in operation. Sudden mechanical failure in the aerial turning gear is extremely unlikely, but periodic maintenance is obviously necessary. On the face of it there is no alternative to 100 per cent duplication of the complete surveillance radar, despite the fact that this will add considerably to the cost of the system. Power supplies are also a critical factor and in at least one case an Ilgner set is used to ensure unfailing continuity.

In the control centre itself a power failure can be equally serious because the store might shed all its information. It would, however, be possible to provide an ancillary store to hold just the basic information or, alternatively, to record all normally stored infor-



The stages by which the L-Band and S-Band radars are refined and combined for presentation on three reporting P.P.I.s. The S-band height finder operates on demand from the P.P.I. joystick-controlled symbols



Above left, an outline of the Marconi proposal for a civil aviation data handling system. The progress controllers have synthetic radar displays and screens showing additional flight-plan information drawn from the store. At right is the Marconi video-map cabinet

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mation continuously on tape. In the event of a power failure the ancillary store would provide a basis for continuing, or the recorded information could be played back into the main store as soon as the power supply was re-established. Information would then be one or two minutes stale, but not entirely useless.

The radar consoles would also have to be arranged to provide immediate alternatives to allow for failure or routine maintenance. Duplicate tubes are already used in a number of raw radar systems. In the last resort, complete duplication of the semi-automatic system by a traditional manual system might be considered desirable, although it would be difficult for it to keep up with the faster working of automatic systems.

Daylight Viewing of Tubes

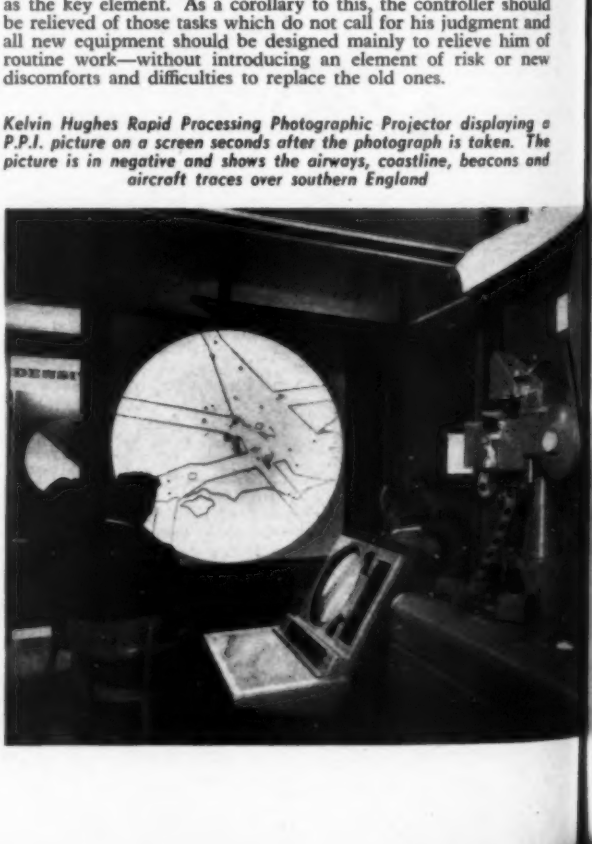
A major technological hurdle to be overcome in introducing extensive radar into control centres is the provision of tubes which can be viewed in daylight. No air traffic controller is at present prepared to accept without reservation a system which requires a darkened room. Besides his raw or synthetic display he must watch other items—even if these are mere tea-cups, pencil stubs and smouldering cigarettes—and must preserve his eyes.

Progress towards daylight viewing is being made in a number of ways. The English Electric Valve Co. have produced a long-persistence memory tube with an extremely bright display which can easily be used in daylight, but tube diameters are at present limited and discrimination is not as good as that of synthetic radar. Other tubes of this type have been developed both in France and the U.S.A., but they too suffer from poor discrimination. The French company, C.S.F.-S.F.R., developed the T.I.440 system for electronically converting radar displays to television pictures, and the Admiral Corporation of Chicago has refined this to produce the Scan Conversion Equipment. Thirty-nine of these units have been ordered for use in American air route traffic control centres. A storage tube capable of retaining radar targets on the display for up to 30 min and building up a tadpole-like trail is incorporated. Both the storage time and trail are controllable. Relatively poor discrimination is still a problem with this system. The T.I.440 is also used by the Régie des Voies Aériennes in Belgium.

Kelvin Hughes in Britain produced a rapid projector which photographs a plan position display once every few seconds, develops the film in a matter of seconds and visually projects the picture either downwards on to a plotting table or horizontally on to a wall-mounted screen. The loss in definition involved in such a system may be to some extent offset by the very considerable magnification which is achieved, but a fairly low ambient light level must be maintained. The film afterwards provides a permanent record. Several rapid projectors have been used in the C.A.A. Development Center at Indianapolis where two such pictures were projected downwards on to a plotting table. In this case, counters bearing suitable identifications were placed over the radar echoes projected on to the plotting table, producing a relatively simple means of identifying the aircraft being tracked. Further application of this system appears limited, though it may prove extremely useful in more general surveillance, such as the first stages of a military early-warning system.

Whatever equipment is adopted, one consideration remains supreme. The judgment of the human controller must be retained as the key element. As a corollary to this, the controller should be relieved of those tasks which do not call for his judgment and all new equipment should be designed mainly to relieve him of routine work—without introducing an element of risk or new discomforts and difficulties to replace the old ones.

Kelvin Hughes Rapid Processing Photographic Projector displaying a P.P.I. picture on a screen seconds after the photograph is taken. The picture is in negative and shows the airways, coastline, beacons and aircraft traces over southern England



Data Link

THE purpose of a data link is to render automatic the transmission of routine information from an aircraft to the control centre and from that centre back to the aircraft. It is generally envisaged that the centre should be able to trigger such transmissions and that the necessary velocity, position and height information, combined with a suitable identification, should be automatically fed into the transmitter. By this means the pilot could be relieved of the task of reporting his position at frequent intervals and the actual transmission would take far less time than traditional voice communication. The capacity of a single radio channel would thereby be very considerably increased and voice communication could be confined to special or emergency messages.

Assuming that the identification and demand signals are effective and that the transmission system works, the information from a data link will be exactly as reliable as the sources from which it is derived. The form of the message will have to be standardized in order to allow universal use; the frequency of transmission will have to be suited to the range and performance demanded; and some standard framework for identification and demand will be required.

Operational trials of an H.F. data link for Decca Dectra are now being carried out over Britain and, in the near future, will be extended over the Atlantic. Satisfactory results have been obtained with H.F. transmissions of Decca Navigator co-ordinates from an Anson to the R.A.E. experimental station at Cove where Flight Log indications in the aircraft were successfully reproduced on a second Flight Log on the ground. A Comet will be used over the Atlantic.

Ultimately, the Dectra data link will be able to handle 200 aircraft, data being transmitted in a digital code as an audio tone modulation of an H.F. carrier between 2 and 8 Mc/s. For an accuracy of 1/64 of a zone in tracking and ¼ zone in ranging, 12 digits will give the tracking fix and 11 that for ranging. According to requirements, further digits will be added to give height and identification. It is estimated that, at a rate of transmission of 20 dots per second, a message giving position, height and identification can be reliably transmitted in 2.5 sec. By the use of conventional Selcal techniques, position reports could be demanded from about 12 aircraft per minute, comfortably allowing for 200 reports every 20 min. But more than one frequency would ideally be used in order to allow for varying distances between aircraft and ground station and to handle the traffic more quickly.

Since the Flight Log display can be reconstituted in the control centre by means of the data link, it would be possible to compute velocities and detect collision courses. Future positions of aircraft could be predicted, or aircraft in a particular height band or belonging to a particular company could be viewed separately. Long-term recording of traffic information would also allow subsequent analyses for statistical or other purposes. Single-sideband techniques are also being investigated with a view to providing longer ranges.

Radio Corporation of America is developing a data link for the V.H.F. or U.H.F. frequencies under a $1.4 million contract from the Federal Aviation Agency. Further details of this project are given in the section dealing with the American airways system on p. 251. A prototype should be available for flight-testing by July so that a final version might be decided upon by the end of 1961.

Airborne indicators used in the IT and T Laboratories' Tacon data link feature dual-purpose meters for actual and ordered airspeed, altitude, bearing, distance and heading, as well as provision for exchange of predetermined printed messages

International Telephone and Telegraph Laboratories have also proposed a data link, in this case to be superimposed on normal Tacan channels. Theoretically 120 aircraft could use the link on each of the 126 Tacan channels available, the additional airborne equipment consisting, according to the company, of one "small black box." A series of 31 coded messages would be available for automatic transmission either from the air or from the ground to effect limited communication. Required height, speed, bearing, course and distance ordered from the ground would be displayed by additional needles or counters in the normal cockpit instruments, as illustrated above.

The I.T.T. data link was originally proposed to the U.S. Navy, but it is stated that it could be applied to the civil Vortac system as well. The use of coded messages would allow their presentation in the aircraft in the appropriate language for the crew. On the ground, the positional and velocity information would be presented as blocks of letters and numerals, together with a tiny arrow indicating course, superimposed in the position of the aircraft relative to a map on a cathode-ray tube.

The Defense Products Division of Fairchild Camera and Instrument Corp. has prepared a prototype of an automatic voice link for ground-controlled interception purposes. A series of suitable words is defined by binary codes of five bits stored on a magnetic drum. When selected and placed in the required order by an operator on the ground, they can be transmitted at intervals, together with words detailing bearings, heights and distances which are continuously modified by the interception computer. In this way basic interception instructions with an identification and continuously up-dated quantitative information could be provided. Speech enunciation would be standard and clear, and the airborne equipment could also be arranged to reproduce the original message in the language understood by the crew.

I.C.A.O. GUIDE *Arbiter of International Civil Aviation*

WHEREAS the future development of international civil aviation can greatly help to create and preserve friendship and understanding among the nations and peoples of the world, yet its abuse can become a threat to the general security; and

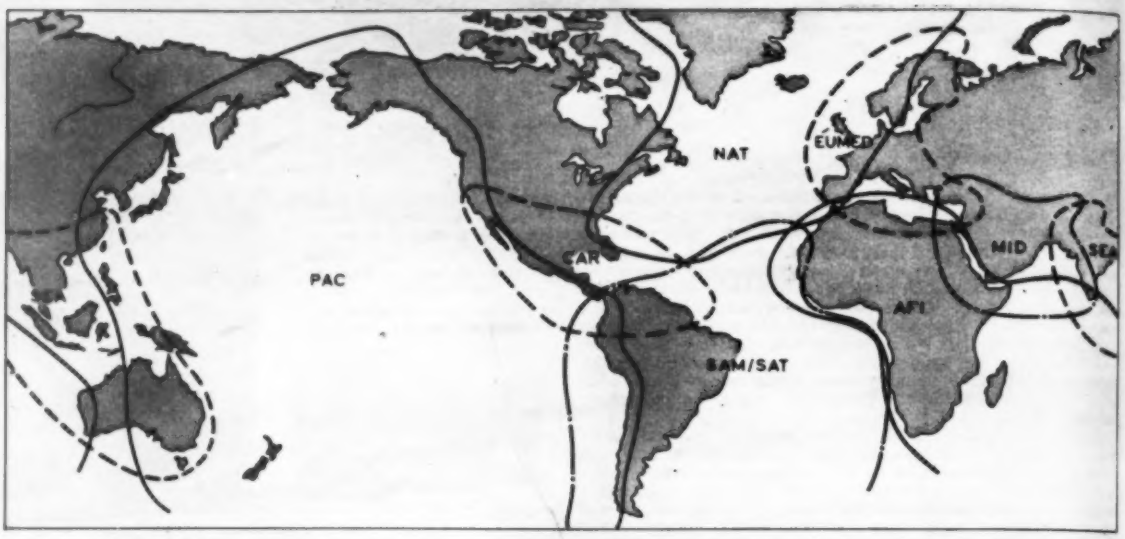
WHEREAS it is desirable to avoid friction and to promote that co-operation between nations and peoples upon which the peace of the world depends;

THEREFORE, the undersigned governments having agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically;

Have accordingly concluded this convention to that end.

THIS is the wording of the preamble to the Convention on International Civil Aviation which was signed by 52 allied and neutral countries in Chicago on December 7, 1944, and in which the present International Civil Aviation Organization had its origin. The convention actually came into force on April 4, 1947, when the instrument of ratification of the 26th contracting state was deposited, and the provisional I.C.A.O. which had been preparing the ground was replaced by the substantive body. In succeeding years many other nations joined I.C.A.O.; the present total of 73 is listed in a table on p. 261.

In October, 1947, I.C.A.O. became a specialized agency in relationship with the United Nations Organization, in the same manner as the World Health Organization, the International Telecommunications Union, the World Meteorological Organization and others. Its purpose is to develop the principles and techniques of international air navigation and to foster the planning and development of international air transport within the general



The eight regions established by I.C.A.O. to delineate the areas for the regional plans. Dotted and solid lines are here used for clarity. The identifying initials are:—PAC, Pacific; CAR, Caribbean; NAT, North Atlantic; SAM/SAT, South America/South Atlantic; EUMED, Europe Mediterranean; AFI, Africa Indian Ocean; MID, Middle East; SEA, South-east Asia. The regions are deliberately overlapped and do not constitute administrative units

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framework of the preamble and the 96 articles of the Convention.

The governing body, the assembly, elects a council of representatives of 21 nations every three years; and this body convenes the assembly periodically at intervals of not less than three years. A full-scale assembly, in plenary and committee sessions, reviews the complete work of I.C.A.O. in the technical, economic, legal and technical assistance fields and gives guidance to various specialist sections of the Organization. At more frequent intervals smaller-scale assemblies are held to discuss financial and domestic business. The next full assembly is to meet at San Diego in June.

In order to carry out the aims of I.C.A.O. the council adopts or modifies international standards and recommended practices; but their preparation—and the specialist functions, such as legal matters and "joint support"—are delegated to the Air Navigation Commission and the Air Transport Committee, the Legal Committee, the Committee on Joint Support of Air Navigation Services and the Finance Committee. The original Convention also provided for the establishment of sub-commissions to deal with particular technical subjects and such bodies were set up in the form of divisions of the Air Navigation Commission and the Air Transport Committee. These are shown in a diagram on page 261. Though membership of each committee or commission is limited, any State may send delegates, alternates and advisors to a divisional meeting. A division is thus democratic and makes recommendations to the committee or commission which, if subsequently sanctioned by the council, can become internationally binding.

Two divisions, those for the facilitation of international air transport (FAL) and for statistics (STA), depend from the Air Transport Committee, and eleven more are offshoots of the Air Navigation Commission. Each is generally known by identifying initials. They are the Aerodromes, Air Routes and Ground Aids Division (AGA), Communications (COM), Accident Investigation (AIG), Airworthiness (AIR), Aeronautical Maps and Charts (MAP), Aeronautical Information (AIS), Meteorology (MET), Operations (OPS), Personnel Licensing (PEL), Rules of the Air and Air Traffic Control (RAC), and Search and Rescue (SAR). A Special Radio Technical Division (COT) originally established by Provisional I.C.A.O. was subsequently merged with the COM Division, which thereby undertook responsibility for both communications and radio facilities such as navigation aids. The AIS Division was formed in 1950.

If the council approves a standard submitted by a division it becomes internationally binding and is written into the Convention in one of the fifteen annexes listed in the table opposite. If for some reason a State cannot or will not adopt a standard, it may file a "deviation," which it will be asked to justify at six-monthly intervals. A less binding requirement is the "recommended practice," which also appears in an annex, but which may be disregarded without filing a deviation.

In certain cases operations may be defined in such detail that they cannot reasonably be constituted as standards or are not suitable for such a measure. They are therefore added to the appropriate annex as a procedure and constitute guidance material for contracting States.

Airworthiness requirements are much more difficult to standardize because of the great variety of national methods, and they are in effect formulated in general terms and illustrated by specially prepared A.M.C.s—"acceptable means of compliance." These give specific instances of airworthiness which are considered as satisfying the generally stated requirements. In cases where it is difficult to lay down hard-and-fast rules because it is too soon to assess new conditions, provisional A.M.C.s are drafted and promoted to full A.M.C.s when and if they are shown to satisfy the requirements. This has occurred during the introduction of the big jet transports.

Between meetings, the work of the divisions is carried on by the appropriate sections of the I.C.A.O. secretariat at Montreal, working under the Air Navigation Commission. This secretariat in fact provides both the technical and administrative support for the council and the other bodies. It organizes meetings and coordinates the establishment of each agenda and it also supplies technical backing during special investigations. With a staff including technically qualified personnel recruited from many countries, it is divided into bureaux and sections corresponding to the commission, committees and divisions. It is headed by the secretary-general, Carl Ljungberg, of Sweden, who will be succeeded in June by R. M. Macdonnell, of Canada. The president of the council is at present Walter Binaghi, of the Argentine.

When a standard has been established additional problems may arise which do not require the relatively cumbersome procedure of a full divisional meeting, or which concern more than one division at a time. Air Navigation Conferences may therefore be called to discuss wider topics, and Special Meetings can cover rather more limited problems. These technical meetings are open to all contracting States; they deal with technical matters of worldwide scope and have no continuing function between sessions. The council may also invite representatives of other international organizations (such as I.A.T.A. and I.F.A.L.P.A.*) and non-contracting States and public bodies to attend as observers.

In addition, the Air Navigation Commission may from time to time establish panels of experts to study particular problems. Those at present in existence are concerned with AIS/MAP, airworthiness, meteorological operational telecommunications network in Europe (MOTNE), radio telephony speech, tele-typewriting, co-ordinating procedures for the provision of information for air operations (PIA), vertical separation between aircraft, visual aids, jet operations requirements and implementation. Of these, the Jet Operations Requirements Panel and the Implementation Panel are perhaps the best known. The six-man implementation panel has now almost completed a worldwide survey designed to assess the most urgent requirements for bringing ground-based facilities up to the required level for present and

**International Air Transport Association and International Federation of Airline Pilots Associations.*

expected air traffic. The other panel is, of course, concerned with the tremendous problems involved in introducing large numbers of turbine-engined airliners on to the world's air routes.

A panel may operate largely by correspondence or it may hold frequent meetings. Its methods are generally adjusted to the particular nature of the task in hand, and it is supported in its work by the secretariat. Special directives are issued to the panels from the Air Navigation Commission, and members are not bound by the rules of procedure laid down for meetings.

I.C.A.O. has established a technical programme for air navigation based on submissions by contracting States. At appropriate times the decision is made to prepare a technical meeting or to set up a panel of experts. Generally, preparation for a meeting takes about two years, during which time an agenda is drawn up and interested States submit papers to form a basis for discussion. Air Navigation Conferences and Divisional Meetings are generally held at the headquarters at Montreal, but panels and other bodies may meet almost anywhere in the world.

Each meeting and panel produces reports, which with other works help to constitute an impressive list of I.C.A.O. publications, particularly so since versions are available in English, French, and Spanish, which are the three recognized working languages. (Publications are obtainable from the I.C.A.O. Distribution Officer, International Aviation Building, 1080 University Street, Montreal, Canada, or from the regional offices in Egypt, France, Peru and Thailand. There are also sales agencies in Argentina, Australia, India, Mexico and in the United Kingdom; in the last-named case the agents are H.M. Stationery Office, and the index of I.C.A.O. publications bears the reference Doc 7680.)

Much of the work of I.C.A.O. has to be planned on a regional basis and for this purpose the eight areas shown in the map opposite have been apportioned. They overlap to a considerable extent, because the peripheral areas necessarily concern each of the adjacent regions involved. The regions are not administrative units. When the Air Navigation Commission decides upon a standard it must be implemented, and Regional Meetings are called for the States in the regions concerned and for those others whose airlines operate through the areas. The meetings divide into sub-committees equivalent to the divisions and a detailed regional plan is drawn up.

In the eight regions the plans involve some 40,000 facilities of all kinds approved by the council. Regional meetings are held at a convenient centre, not necessarily within the region concerned. Encouragement and assistance in implementation (a familiar I.C.A.O. term) of the regional plan is to some extent the responsibility of regional offices at Paris, Cairo, Lima, Bangkok and Mexico, each of which is accredited to a group of states. The regional offices are not directly connected with the I.C.A.O. geographical regions.

In many instances facilities must be set up in a country although they are far beyond the requirements or resources of that country. The weather stations and navigation aids in Greenland, Iceland and the Faroes for North Atlantic traffic are particular examples —as are the Atlantic ocean weather ships, which are, of course, in international waters. A "joint support programme" is therefore established to provide or assist in providing the installations, and the money is contributed by interested States according to the use they make of the facilities. This is the main purpose of the Joint Support Committee.

Also produced by I.C.A.O. are statistical surveys of air transport operations, an example being that prepared for the Universal Postal Union on air mail costs and rates. Multilateral agreement on commercial air rights between nations was thought to be desirable in the Convention, but no universally accepted formula has been found and more than 400 bilateral agreements have so far been concluded instead. The original Five Freedoms specified in the transport agreement have been ratified by only 11 nations, although the European Civil Aviation Conference of 19 west-European nations has developed a multilateral agreement on non-scheduled air services. Another major I.C.A.O. activity is in providing technical assistance to smaller countries in all phases of civil aviation, from infrastructure and aircraft maintenance to the training of aircrews.

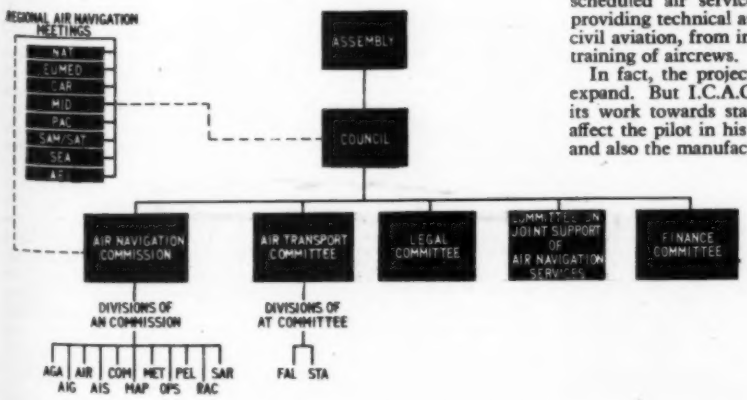
In fact, the projects are legion and the work will continue to expand. But I.C.A.O. is mainly known, and most powerful, in its work towards standardization. It is here that it can greatly affect the pilot in his cockpit and the passenger on his journey—and also the manufacturer in his factory.

THE 73 MEMBER STATES

Afghanistan	Ghana	Netherlands
Argentina	Greece	New Zealand
Australia	Guatemala	Nicaragua
Austria	Haiti	Norway
Belgium	Honduras	Pakistan
Bolivia	Iceland	Paraguay
Brazil	India	Peru
Burma	Indonesia	Philippines
Cambodia	Iran	Poland
Canada	Iraq	Portugal
Ceylon	Ireland	Spain
Chile	Israel	Sweden
China	Italy	Switzerland
Colombia	Japan	Sudan
Costa Rica	Jordan	Thailand
Cuba	Korea (Republic of)	Tunisia
Czechoslovakia	Laos	Turkey
Denmark	Lebanon	Union of South Africa
Dominican Republic	Liberia	United Arab Republic
Ecuador	Libya	United Kingdom
El Salvador	Luxembourg	United States
Ethiopia	Malaya	Uruguay
Finland	Mexico	Venezuela
France	Morocco	Viet-Nam
Germany		

ANNEXES TO THE CONVENTION

1 Personnel Licensing	*Licensing of operating and maintenance personnel.*
2 Rules of the Air	*Rules relating to visual and instrument flight.*
3 Meteorology	*Codes, meteorological communications and meteorological services.*
4 Aeronautical Charts	*Standardization of charts for use in international aviation.*
5 Dimensional Units to be used in Air-ground Communications.	*Reduction in the variety of dimensional systems.*
6 Operation of Aircraft—International Air Transport.	*Specifications which will ensure in similar operations throughout the world a level of safety above a prescribed minimum.*
7 Aircraft Nationality and Registration Marks	*Requirements for registration and identification of aircraft.*
8 Airworthiness of Aircraft	*Certification and inspection of aircraft according to uniform procedures.*
9 Facilitation	*Easing of international travel regulations (responsibility of Air Transport Committee).*
10 Aeronautical Telecommunications	*Standardization of communications systems and radio air navigation aids.*
11 Air Traffic Services	*Establishment and operation of air traffic control, flight information and alerting services.*
12 Search and Rescue	*Organization of facilities and services necessary for search and rescue.*
13 Aircraft Accident Inquiry	*Uniformity in the notification, investigation of and reporting on aircraft accidents.*
14 Aerodromes	*Characteristics and equipment for aerodromes used in international air navigation.*
15 Aeronautical Information Services	*Uniformity in methods of collection and dissemination of aeronautical information.*



The organization of I.C.A.O. with its commission, committees and divisions. Full wording for the abbreviations is given on page 260

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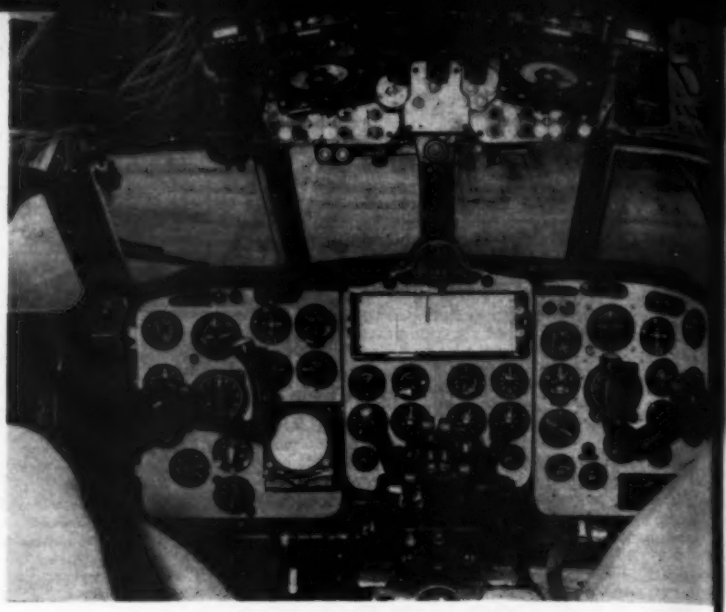

The Decca Flight Log, Decometers and Dectra range meter on the central panel of the M.o.S. Comet 2E cockpit

NAVIGATION

Airborne and Ground-Based Systems

THERE is virtually no danger of an airliner becoming lost in this day and age. Conventional plotting and observation, combined with information obtainable from any of the traditional radio equipment such as A.D.F., Loran and probably V.H.F. and H.F. can provide sufficiently accurate knowledge of position to make arrival at destination a foregone conclusion.

But intensive development of navigational aids is still necessary because the problem is now not so much how to get there but exactly what track should be made good and what stage along a given track has been reached at any time. The fact that the traditional navigating skills are fast disappearing from the flight deck is an additional factor, at least on the shorter range operations; and the speed of aircraft is increasing to an extent where time becomes critical.

A revival of the art of astro-navigation has taken place in bomber flying where independence of ground-based aids is considered essential and cruising heights are high enough to ensure a view of stars unobscured by cloud. But already the independent automatic systems such as inertial navigation, automatic star tracking (and combinations of these two) and Doppler/inertial are spreading from the exigent but relatively short-term missile field and entering what is in some ways the more difficult field of conventional fixed-wing operations. A notable example is the Doppler/inertial hybrid AN/ASQ-42 bombing and navigation system made by Sperry for the Convair B-58 Hustler.

The stable platform element of an inertial system is inherently suitable as a source of attitude information for flight control and such additional use has been made of it in ASQ-42. The possibilities have been carried a good way further in the inertial system supplied by Sperry for the North American X-15 research aircraft. In the absence of atmospheric sources of dynamic flight data at extreme altitudes a complete flight-instrument system is here supplied from inertial data. This is described in greater detail in a later section of this account.

The frequency reference of a stability so far only rarely attained even in laboratory conditions could, if produced in a form for installation in aircraft, allow precise navigation of high-speed aircraft with relatively simple ground-based apparatus. It could additionally afford discrete communication, aircraft identification and position reporting as part of a single integrated system. One such device was developed by the National Company in America, using the resonant frequency of the cesium atom as a reference. First details were published during 1956 and at that time an airborne version weighing about 60 lb was forecast. Since then virtually nothing has been heard of this equipment.

A Vortac ground-beacon, in this case made by International Telephone and Telegraph Corp. The Tacan aerial is the smaller unit above the cone housing the VOR aerial

The earth satellite for navigation has particular advantages since its radiations would penetrate cloud cover which obscures stars and because its high speed would make it possible to provide world-wide cover with one satellite. Both the actual path and the time along the path have been very accurately maintained by satellites so far launched. Either direction-finding or Doppler techniques could be applied to assessing position. At 200 miles above the earth the horizon distance would be 1,100 miles and very high frequencies above 100 Mc/s offer good possibilities of avoiding path distortion of the signals when passing through the ionosphere. A navigation satellite is obviously a costly project which would either become a military prerogative or have to be supported internationally.

Within the sphere of influence of I.C.A.O., navigation aids are to some extent internationally standardized, the present short-range system being the American V.H.F. omni-directional range, VOR.

A very considerable number of VOR beacons has been set up in the U.S., but the number installed in other areas is not large enough to be able to claim that the I.C.A.O. standardization requirements have yet been fully implemented. This can be ascribed in part to the fact that a very large number are required to provide the coverage envisaged.

Compared with other aids at present in use, VOR is very popular among pilots, particularly because it is simple to use, but it has certain fundamental limitations which have become apparent even before complete implementation is accomplished. VOR is not exceptionally accurate, an average estimate of total errors in the system being of the order of five degrees in bearing. Some estimates put the total VOR errors as high as 10 deg. Though this might be acceptable for purely navigational purposes at moderate altitudes, it will not suffice in dealing with high-density traffic on crowded airways. Even the addition of the distance-measuring facility now afforded by the Vortac system is not likely materially to improve this situation.

VOR operates at a fixed frequency in the V.H.F. band between 112 and 118 Mc/s and has a working range of about 130 miles at 12,000ft. Since it transmits along a line of sight, its range and coverage at lower altitudes is reduced and subject to terrain conditions. The beacon transmits two modulations on a V.H.F. carrier, one being a fixed-phase reference signal and the other having a phase delay in relation to it which corresponds to the bearing of the receiver in the aircraft. The bearing is displayed on a meter or, alternatively, the heading error with respect to a chosen radial set on a selector can be shown by a left/right pointer. The latter feature is particularly important since it makes possible the use of a selected VOR radial bearing as a reference for steering information in an integrated instrument display.

All the principal manufacturers of flight instrument and radio navigation equipment, both in America and Britain, have produced integrated displays using this principle. Guidance for I.L.S. localizer and glide-path flying have also been incorporated and the variations in instrument presentation and performance are many. For such purposes VOR has proved to be extremely flexible and has led, during recent years, to something of a revolution in semi-automatic flight.

[*Continued on p. 263*]

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Automatic capture and following of a selected VOR radial and an I.L.S. localizer beam has made the autopilot-controlled approach down to heights of about 200ft a routine procedure.

Distance measuring using an interrogator/responder technique was first developed as a military aid and later applied to civil jet operations. Both Ultra and Murphy in Britain have produced D.M.E. under the military code-name Rebecca and the Comets which first flew with B.O.A.C. used the system in order to judge the right point at which to begin the let-down from cruising altitude. Rebecca Mk 8 has been developed to the stage where it is accurate enough for pilot-interpreted approaches in bad weather down to minima which compare favourably with those allowed under I.L.S. or G.C.A. guidance. Another type of D.M.E. was extensively installed in Australia for civil use in conjunction with VOR and proved both popular and useful in traffic control. But it is officially stated that the VOR/DME combination is not considered suitable for traffic control purposes in high-density traffic in Australia.

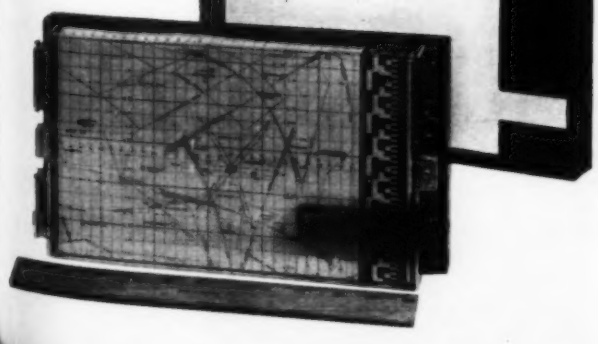
VOR and DME require separate receivers and aerials, but it is possible to perform both the bearing and distance measurement in a single equipment. In order to effect this, and also to provide a beacon system which could be operated from ships and submarines, the U.S. Navy some years ago produced Tacan. The U.S.A.F. also adopted Tacan and the system was then proposed as a new joint civil/military aid to replace VOR. Vigorous opposition came from the civil agencies, but a compromise was adopted when the A.T.A., who proved to have the casting vote, was looking for a distance-measuring system to be available by 1959 for the big jet transports.

The compromise was that VOR beacons should be co-located with Tacan so that military aircraft could use Tacan while civil operators continued to derive bearing information from VOR and used the distance-measuring element of Tacan. The DME portion of Tacan, known as DMET, is at this moment being proposed as an international standard aid to complete the original VOR/DME requirement. Tacan has been standardized in NATO air forces and is being gradually introduced into service. Installation of Vortac is also proceeding slowly in the U.S., with a total of about 1,300 Vortacs planned for 1962. The sum invested in the system is variously reported as between $500 million and $800 million.

Tacan beacons have a range of about 200 nautical miles in the line of sight and bearing accuracy considerably better than that of VOR. Beacon transmitter frequencies are in the U.H.F. band between 962 and 1,024 Mc/s and between 1,151 and 1,214 Mc/s, with the responder frequencies for the DMET element lying between the two. Any number of aircraft may derive bearing information simultaneously, and up to 120 can interrogate the DME responder at a time. Any one of 126 channels may be selected by rotary switches in the cockpit and both distance and bearing information are presented (in the Standard Telephones version) on one dial in the form of meter and veeder indications. Tacan was originally developed by International Telephone and Telegraph Corp and is manufactured in this country by Standard Telephones and Cables, Ltd. Complete test equipment is made in this country by G. and E. Bradley, Ltd.

The American armed services now regard Tacan as an interim navigational aid, intending apparently to introduce other systems as they become available. Such rapid replacement is not feasible in civil operations and the declared intention is to make the utmost use of Vortac by adding further refinements in future, and to keep it in being as the basic American aid for many years to come. Whatever aid replaces VOR as the I.C.A.O. standard, Vortac is to be maintained in the U.S. The colossal investment is not lightly to be thrown away.

Self-setting Decca Flight Log showing the digital tracks and photo-sensitive scanning unit beside the chart



The navigator's position in the B-58 Hustler, showing the controls for the Sperry stellar-inertial bombing and navigation system (see p. 266)

The Jet Operations Requirements Panel of I.C.A.O., the American Curtis report in its Phase 2 recommendations, the International Federation of Airline Pilots Associations and the British Ministry of Transport and Civil Aviation have individually stated that a point-source aid of the VOR or Vortac type will not allow the necessary flexibility or accuracy required for traffic-control purposes and that an area-coverage system is considered necessary. Three of them also stated a requirement for pictorial indication in the cockpit. Each body made its own detailed investigation of the requirements. The reasoning which led the M.T.C.A. to favour an area-coverage system was recorded in *Flight* for January 23.

There is a sharp division of opinion between America and much of the rest of the world on what a new navigational aid should be. The whole question is at this moment being thrashed out at a technical meeting of I.C.A.O. in Montreal. It would be rash to predict either a clear-cut solution or one based purely on technical considerations. Much more is involved.

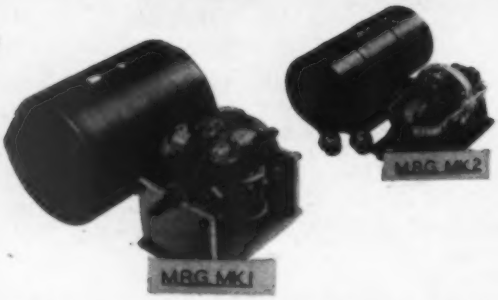
In recording the general considerations from the technical point of view it is well worth summarizing the United Kingdom views on the situation if only by way of establishing a small monument. Britain, of course, supports the Decca Navigator system which is still the only area-coverage system to have been extensively used in airline operations and for which a considerable coverage of ground stations already exists. It should be remembered that it is the Decca Mk 10 system on which the Ministry bases its confidence.

The M.T.C.A. notes that navigation requirements are today dictated by traffic control requirements and infers that they should not be dominated by military thinking which was originally responsible for VOR and Tacan. Both the capital and maintenance costs of these systems is in any case unnecessarily high and DMET is more complex than an equivalent designed specially for civil use.

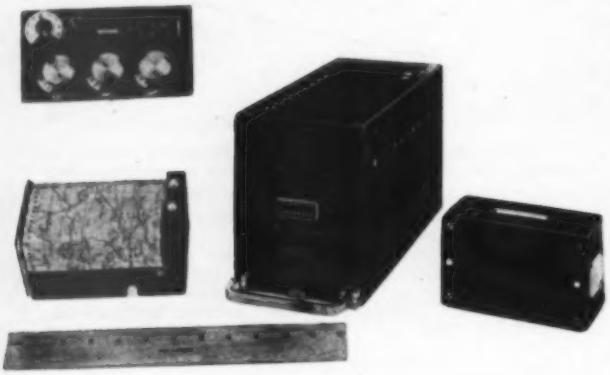
Vertical separation alone is unsuitable for jet airliners because of the severe economic penalties imposed by operating at other than the ideal altitude. The ability to enforce lateral separation is therefore an important requirement for traffic control.

The M.T.C.A. is convinced that the real requirement is for an aid which will:—

(a) reduce lateral as well as longitudinal separation minima;
(b) enable greater use to be made of lateral separation in order to provide the greatest possible freedom in the vertical plane;
(c) be capable of serving any air-route configuration without the costly, lengthy and difficult process of redeployment of ground facilities;
(d) give the required quality of short-distance navigational service over sea areas;
(e) permit flexibility in the siting of holding patterns and economy in their size;
(f) enable pilots to make smooth and accurate approaches to both instrument and non-instrument runways;
(g) provide accurate navigational information to helicopters as well as to high-flying turbojet aircraft;
(h) provide the pilot with a continuous and accurate presentation of his position in a manner which will enable him to follow the desired track during all stages of the flight;



Above, the Mk 1 and 2 Master Reference Gyros made by S. G. Brown Ltd. Below, the miniature, integrating-type Decca Navigator installation for small aircraft



(i) be capable of integration with long-distance navigation aids so as to accommodate additional equipment progressively as the requirements develop;
(j) be easy to site and maintain;
(k) require no regular air calibration checks; and
(l) provide a high coverage/cost ratio.

Significant developments are now taking place in Decca airborne equipment and some of these have already been mentioned in *Flight* during recent weeks. Both the Mk 10 and the Mk 8 receiver are being miniaturized. The first Mk 10, designed for S.B.A.C. racking, retains existing constructional practice as far as possible in order to reduce the number of new features to the practicable minimum. The Mk 10A, which is now going into production, is basically the same but contained in a long 1½ ATR case. In anticipation of the requirement for duplicated receivers, Decca are now working on the miniaturized Mk 10B which will fit into a long ½ ATR case. It will be largely transistorized and, since the power requirements will be greatly reduced, the power unit will be incorporated in the Flight Log computer case. An additional 150 cu in of space will be saved by more than halving the size of the 50 coil cans in the Mk 10. The combined computer and power unit of the Mk 10B will be housed in a long ½ ATR case. Further circuit refinement in the computer will lead to the elimination of the three Decometer movements now used. The stud switch which is the basis of the present scale-changing facility will be replaced by a printed circuit disc. Both the present and the miniaturized computers can handle Decca and Dectra inputs.

It is not considered desirable to reduce the surface area of the Flight Log, but the new Type 860 display head, which is now available, has a depth of only 1⅞in compared with the 5¾in depth of the current Type 331 head.

The Dectra receiver corresponding to the Mk 10B will be contained in a long ½ ATR case. In this form it will have many more stages and components than present Dectra receivers which are designed for use only with the North Atlantic Dectra chain. Most sections of the receiver lend themselves well to the application of transistors, but a small number of sub-miniature valves may be retained in miniaturized versions.

A new Mk 8 receiver, making full use of the available pattern sensitivity, is being produced for special purposes such as surveying, and a version of this known as the Mk 8A and housed in a long ½ ATR case is to be introduced. The miniature RF channels and other relevant transistorized sections of the Mk 10B will be available for other receivers and one of these will be a Mk 8B in a long ½ ATR case.

Decca receivers have been designed for use in helicopters, business aircraft and small military aircraft such as fighters. There are two types, the Mk 9 which consists of five units including an aerial amplifier and weighs 20¾ lb and a Bendix/Decca receiver consisting of three units weighing altogether 21 lb. The Mk 9 has been in production for a number of years and has had extensive operational use. It employs the principle of lane integration for the resolution of pattern ambiguity, the small size of the receiver being made possible by the omission of the lane identification facility. It is highly accurate and employs a special miniature Flight Log weighing 4 lb and measuring 3½in x 6½in x 4½in. Later versions of the Mk 9 will be transistorized and, in the smallest aircraft, the Flight Log could be eliminated with a saving of 4 lb. The Decometers alone, the Flight Log alone or both together could be used.

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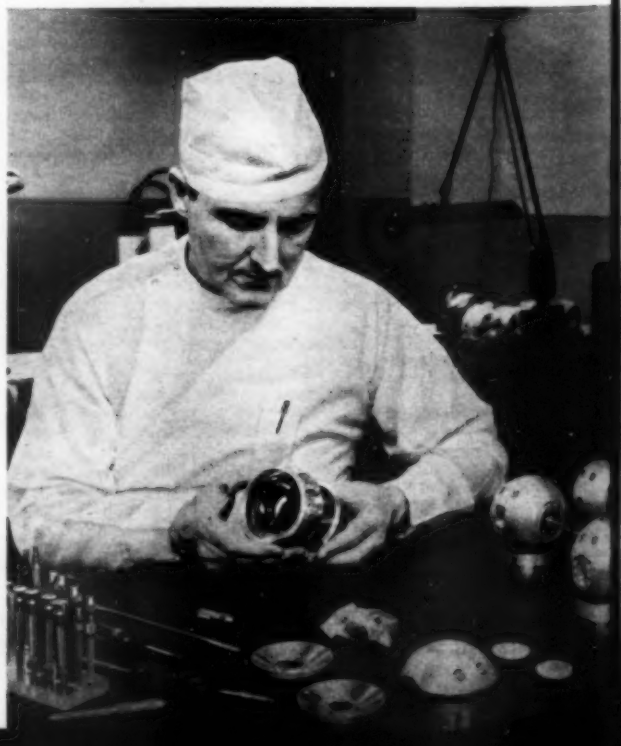
The Bendix-Decca light aircraft receiver uses the Mk 10 chains and derives a pair of position line readings three times per minute in terms of coarse hyperbolic patterns generated by the Mk 10 transmissions. There are only two R.F. channels in this receiver and two Decometers, the latter built into the receiver itself. They are switched to whichever two of the three available hyperbolic patterns have the best angle of cut at the user's location. Readings derived from the brief Mk 10 transmissions are held stable until the next transmission.

This Bendix-Decca receiver contains only zonal ambiguity, the effect of which will be negligible at the airspeeds involved. The pilot need only be able to set the correct zone letter for each pattern and the receiver will set itself up of its own accord. Either the two Decometers or a combined Flight Log and computer, now being prepared by Bendix, may be used. The Decca Mk 9 and the Bendix-Decca light aircraft receiver use power supplies respectively at 24 V D.C., 7 A and 28 V D.C., 2 A.

While the Mk 10 receiver can be easily set up for operation and chart characteristics can be simply changed, a fully self-setting facility is to be incorporated in a Mk 3 Flight Log which is now in an advanced stage of practical development. In this case a different computer system incorporates digitizing discs which derive binary code quantities from the incoming red, green and purple angular values. The digital computations produce X and Y outputs, still in terms of the binary code, which are fed to the appropriate co-ordinate of the Flight Log.

Six tracks printed along the edge of the Flight Log chart are illuminated by miniature lamps and the output from six corresponding photo-transistors then records the binary code quantity represented by the markings intercepting the light at any instant. The number of digits, and therefore of lamps, can be increased to eight or nine. The output of the phototransistors is compared with the digitized output of the receiver in the corresponding co-ordinate and the resulting error signal is made to turn on the paper-drive motor until the difference is zero. Because slipping of the paper over the rollers is no longer important the sprocketed drive is eliminated. The pen is driven across the Flight Log in a similar manner although a printed track system obviously is not

Assembling a floated inertial-quality gyro in a dust-free, air-conditioned room at the Autonetics division of North American Aviation



Part of the assembly line for the stable platforms of the Achiever inertial guidance system made by A.C. Spark Plug division of General Motors for the Douglas Thor. Part of the computer for the same system is illustrated overleaf

used. Any momentary errors in the computation are not carried forward and paper distortion is not important.

With such a system the pen would only have to be placed somewhere within a certain area of the chart and it would then immediately drive itself to the exact chart position. For chart changes the tracks on the two charts would no longer have to be aligned (as they are in other versions) and this makes the choice of chart arrangements easier. In addition, the optical pick-off tracks could be used to set the computer to the requirements of a particular chart, thus dispensing with the turret switch and keys. The phototransistor assembly is small and does not obscure or confine the chart. It could also be used to trigger certain secondary indications such as command heights along a glide-path and these could further be compared with the output of a radio or barometric altimeter to show whether an aircraft is above or below a glidepath.

Although the present range of charts is arranged to avoid extensive distortion of the topographical picture there are still a few areas in which this must occur. Both for the sake of the human operator and for ease of coupling to automatic devices, a distortion-free presentation is desirable. Decca have been working on a digital computation system for converting hyperbolic into rectilinear co-ordinates, and the self-setting Flight Log described above is envisaged as part of such a system, although it can also work with the present type of chart. The main problem has been one of reducing the size of the computer, but flight tests are expected before the end of 1960. Analogue solutions could also be applied in cases where accuracy and flexibility were not essential and a practical approach with this method is being made.

Yet another approach has become possible as a result of DIAN which combines Doppler with Decca/Dectra. In this system the Doppler output is converted into X and Y co-ordinates and displayed on a Flight Log chart which is effectively distortionless since the plotting axes are at right-angles. The Flight Log could be directly driven by the Doppler output and the Decca or Dectra co-ordinate values used to monitor and correct the Flight Log display.

Yet another Decca development is coupling to an autopilot or a left/right meter. Of the two main methods of doing this, one involves an optical pick-off on the Flight Log head, the required track being represented on the chart by a black/white boundary. The pick-off would be part of a servo loop seeking to hold the head in a position giving a specific ratio of black to white. The Flight Log stylus could either be coincident or offset from the point of pick-off.

The other coupling system has been developed for the Decca system by Sperry Gyroscope Co. and is also applicable to other aids such as VOR/DME. Flight tests already carried out have shown that the accuracy of guidance is no less than that of the basic information. The principle is that the co-ordinates of departure and destination or of the destination alone, with or without a series of way points, will be registered on a punched card driving digital servos to set up the parameters for each leg. It can, of course, be foreseen that a duplicate punched card could be passed to an air traffic control centre to form an automatic flight plan which could be fed into a computer. Conflicts between two or more flight plans could then be rapidly computed and suitable adjustments made. Sperry's Prince aircraft has, for the trials, been fitted with a Zero Reader Flight Director, A.L.30 Gyro Pilot and a Decca Mk 8 receiver. The computer used to transform the hyperbolic Decca co-ordinate readings into track error and distance-to-go combines accuracy with simplicity and defines straight tracks throughout the cover, except close to the master transmitter. Ten miles from this, the distortion is trivial and at 25 miles it can hardly be discerned. Sperry are investigating the application of this coupler to all-weather helicopter operations.

This method of coupling resembles an early Decca device called "Ghost Buoy." If the co-ordinates of the destination alone are set in the computer, the left/right signal is constantly related to the shortest course to the destination regardless of aircraft position.

Apparently in an attempt to provide a new approach to the area-coverage problem, International Business Machines some time ago carried out initial studies of a system called Automatic Position Telemetering. The system has been nick-named "rho rho rho rho" because it relies on computation of aircraft position derived from four distance-measuring signals. A traffic control centre would instruct an aircraft to transmit on a given U.H.F. frequency a series of pulses whose time of arrival could be measured simultaneously by four receivers on the ground spaced in a square with 20-mile sides. Overall time coincidence would be provided by a special pulse sent from the ground. Time-sharing of the single frequency would allow it to be used by a number of aircraft.

The arrival times of the pulses would be passed to a co-ordinate-conversion computer and fed into the traffic control data system. An accuracy of 0.05 miles within the square and 1.5 miles at a range of 90 miles is claimed. The airborne equipment would be very light and the positional information would be compatible with the Data Processing Central described on p. 251.

Besides Decca Navigator and Dectra, a number of other area-coverage aids are in varying stages of development although none of them appears to have gone beyond trial installation. Certainly none is as far advanced in operation as the first two. The principal examples are Loran C, formerly developed by Sperry as Cytac (cycle-matching Loran), Omega, Navarho and the French Radio Mailles or Radio Web. *[Continued overleaf]*

Part of the computer for the Achiever inertial-guidance system made for the Douglas Thor by A.C. Spark Plug division of General Motors

Inertial Navigation

The development of inertial-quality equipment has reached a point where the special gyros used for stable platforms (and in some cases as accelerometers) are small and cheap enough to be incorporated in master dynamic reference systems. While it is safe to say that genuine inertial navigation is not likely to find a place in airline use for some years to come, a number of master references are being planned to include inertial-quality gyros so that they are theoretically capable of being applied not only to flight control and instrumentation but also to short-term navigation.

Under the stimulus of military requirements during the development of the ballistic missile, tremendous progress was made in inertial design in a relatively short time. Many different approaches were tried and a great variety of gyros, accelerometers and computers is now available. But because the main application was in missiles with a flight time of about 30 minutes, the first few minutes of which would give anything an exceedingly rough ride, the main effort went into short-term systems capable of withstanding a distinctly hostile environment.

In its review of flying aids of May 16 last year, *Flight* recorded that inertial systems were not yet suitable for long-term navigation such as might be required during a trans-Atlantic flight. The subsequent voyages under the polar ice cap by the nuclear submarines *Nautilus* and *Skate* proved that a long-term inertial system, typified by the Autonetics Ships Inertial Navigation System (SINS), had now come of age. The application of a similar long-term pure-inertial system to aircraft use depends mainly upon reducing the weight of the equipment and increasing its tolerance to vibration and extreme temperatures.

Although work began on inertial systems in Britain at a relatively early date, rapid advances were mostly made in America where financial backing was virtually unlimited. The following record of achievement by the Autonetics Division of North American Aviation is, in view of this, not surprising, though nonetheless impressive. Autonetics flew the first "all-inertial autonavigator," the XN-1, in a C-47 in May 1950. Since then more than 800 flights with various systems have been made. During 1952 the XN-2 stellar-inertial autonavigator successfully tracked stars automatically during flights in daylight and picked up stars at night after the aircraft had taken off and climbed above cloud. By 1954 Autonetics had produced a completely manœuvrable inertial platform and was currently testing five inertial systems of three different types. The following year a stellar-inertial system guided a U.S.A.F. T-29 during a 13½ hr flight from Los Angeles to Patrick A.F.B., Florida. During 1956 a pure-inertial system guided the X-10 experimental vehicle through an out-and-return flight of several hundred miles at supersonic speeds. It also guided a test version of Navaho at Mach 3. By 1957 Autonetics had achieved in-flight alignment of an inertial navigation system from a cold start using an independent velocity reference. An idea of cost can be gained from the fact that development of the inertial guidance system for Titan by the American Bosch Arma Corporation cost slightly over $140 million.

A stable platform for the Sperry inertial system for the B-58 Hustler being tested in a transport aircraft

The first production application of an inertial system to a manned military aircraft is the AN/ASQ-42 primary navigation system made by Sperry for the Convair B-58 Hustler. Almost a hundred of these aircraft are being ordered. Late Republic F-105s and the North American A3J Vigilante will have inertial systems. The ASQ-42 is, in fact, a Doppler-inertial hybrid capable of providing accurate information over a period of hours. It is probable that the Doppler element would be used only intermittently to check the inertial element. In addition to providing navigational information, ASQ-42 supplies attitude and other information to nearly a dozen sub-systems such as those for reconnaissance and flight control. The navigation system can operate anywhere in the world and will automatically control the release of the Hustler's 50ft-long pod. The ASQ-42 is 20 per cent lighter and occupies 37 per cent less space than present systems such as that of the B-52, and it is claimed that it is more versatile and reliable.

In Britain, the Sperry Gyroscope Company flew an inertial navigator designed for manned fighters in November 1954. The company now holds the contract for development of the guidance system of the British ballistic missile. English Electric announced last year an agreement under which they will produce some of the range of Miniature Integrating Gyroscopes designed by Minneapolis-Honeywell in America. In addition to producing this equipment under licence, English Electric are designing complete stable platforms as well as the necessary gyroscopes for them. Elliott Brothers (London) Ltd. are designing the inertial navigation system for the Avro stand-off bomb.

During last year's S.B.A.C. Display, one of the six Miniature Stable Platforms which had then been produced by Minneapolis-Honeywell was publicly displayed for the first time. Although intended as a master dynamic reference, it is based on three GG49 Miniature Integrated Gyros which are of inertial quality. The two units comprising the platform weigh a total of about 40 lb, can be started up in three or four minutes and do not require a highly stable power supply. In one application, thirty different outputs have been supplied. Instead of being used as a master dynamic reference, M.S.P. can be used as a short-term or hybrid inertial system.

Five years ago S. G. Brown Ltd. produced the first two-gyro master reference unit (described in *Flight* for April 12, 1957). The Mk 1, which is fitted in all the latest British fighter and very high speed research aircraft, has now been succeeded by the Mk 2 which is 14in long, 7in wide and 8½in high, including the mounting frame and amplifiers. Because the vertical and azimuth gyros are set in line with the fore-and-aft axis of the platform their wheel diameters and therefore their efficiency have been increased. The rate of roll of the platform is 450 deg/sec. Only a 115 V, 400 c/s, three-phase power supply is required. The gyros have random wander rates of better than 0.25 deg/hr and platform vertical accuracy is 0.2 deg. A computer introducing appropriate signals to allow for the earth's rotation, sphericity and coriolis accelerations can be provided if the M.R.G. Mk 2 is to be used for navigational reference.

S. G. Brown last year concluded an agreement with American Bosch Arma (and not with Kearfott as stated in *Flight* for September 12, 1958) providing for an exchange of information. As a result of this, a Mk 3 M.R.G. is being planned to incorporate a pair of two-degree-of-freedom, Arma-Brown floated gyros. This equipment will be suitable for inertial navigation purposes.

The Sperry Rotorace vertical gyro, with the remarkably low drift (for a non-floated unit) of 0.25 deg/hr, has now been in service with Sperry C-11 compass system for more than a year. In this equipment gimbal-bearing imperfections are to a great extent cancelled out by rotating the concentric ball-bearing housings at about 20 r.p.m., the direction of rotation being

periodically reversed. Last year, Rotorace was incorporated in a two-gyro stable platform produced for the U.S.A.F. The equipment was so arranged that random drift of the integrated horizontal and directional axes was 0.25 deg/hr and drift of the vertical axis, 0.1 deg/min. The whole unit weighs 26 lb. This master gyro system is now to be manufactured in Britain by the Sperry Gyroscope Company.

Doppler Navigators

One of the keenest commercial sales prospects at the moment is that of Doppler radar. At least a score of companies in America are producing equipment of this type for a variety of military applications, and R.A.F. V-bombers have carried the Marconi Doppler for many years. The Marconi AD.2000 and 2100 and the Decca Type 60 and 61 (and their combination with Decca/Dectra in DIAN) have been described in *Flight* during the past two years. Ryan Aeronautical has been producing a number of Dopplers for the U.S. Army and Navy and General Precision Laboratories have supplied many sets to the U.S.A.F. Extensive trials in military service have established accuracies and reliabilities of a high degree. Some of the main considerations in designing Doppler equipment were enumerated in *Flight* for May 16 last year. Doppler will provide extremely accurate information on groundspeed and drift, although the accuracy of its magnetic-track information will be determined by that of the compass system with which it must work.

The present commercial situation is keenly competitive. In Britain, Marconi are offering the AD.2300 and Decca Radar a Doppler alone or DIAN. The AD.2300 has been demonstrated in public, as recorded in *Flight* for May 16 last year. In America, G.P.L., Bendix, Collins and R.C.A. are preparing civil Dopplers. The G.P.L. Radan has been evaluated by PanAm and installed in one of the survey aircraft of Aero Service Corp. No extensive details of the Collins equipment have yet been released, but details of the Bendix RDA-12 have been published. R.C.A. have an agreement with Marconi in Britain.

The company which has so far achieved the largest firm orders is Canadian Marconi. They have announced a contract worth $150,000 from K.L.M. and a further order from another major airline, bringing the total up to $250,000. The Dopplers for K.L.M. are for installation in their Douglas DC-8s which are to enter service in 1960.

The Canadian Marconi equipment, called CMA-620, is an FM/CW system transmitting ¼W power at 8,800 or 9,830 Mc/s. The aerial is a four-beam, janus layout of linear, slotted waveguides, stabilized in pitch and rotatable through ±30deg. The radiated beams converge before leaving the aircraft, reducing the size of cut-out needed. The whole equipment weighs 70 lb and includes transmitter/receiver, tracker and power supply in a single 1 ATR electronics package. For ARINC characteristic 540, the transmitter/receiver and the remaining units can be separately housed in cases respectively of ½ and ¼ ATR size. In the tracker, the received Doppler spectrum is compared with the frequency of a highly stable variable oscillator. An automatic lock-checking circuit causes a warning light to shine within 20 sec of loss of signal. A specially sensitive setting is automatically selected over calm sea. A CMA-621 behaved extremely well during trials in a PanAm DC-7 late last year.

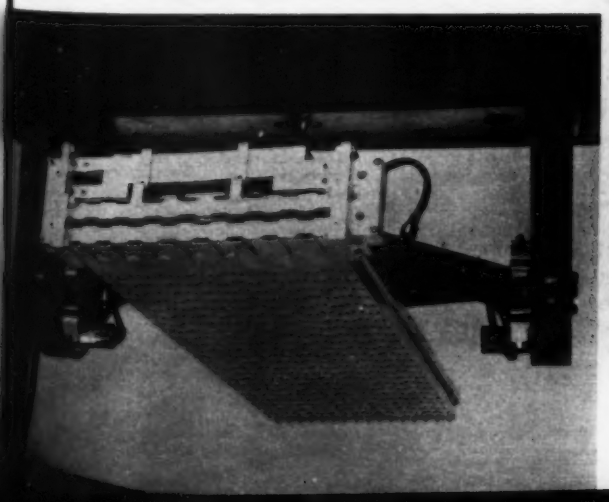
The Computing Devices of Canada transistorized Doppler computer called Skyline, which weighs altogether 13.8 lb and shows distance along and across track and heading and drift on a single dial, has been adopted as the indicator for the Bendix DRA-12 civil Doppler which is now undergoing first flight trials in a Beech 18. The DRA-12 is an FM/CW, four-beam system weighing 60 lb and was described in *Flight* for November 28 last year. A duplicated version would weigh 103 lb.

General Precision Laboratories seem to have been the first to attain trials in scheduled airline service when an early example of their PC-201A Radan made about 18 crossings of the north Atlantic in a PanAm DC-7C. A report on its characteristics and performance during these trials was given in *Flight* for May 16 last year. Radan then weighed 125 lb and used a pulse transmission system at 8,800 Mc/s with a power of 10W. In its report, PanAm stated that the autopilot-coupling facility and distance-gone indication "proved to be of inestimable operational value." Most Dopplers provide this coupling.

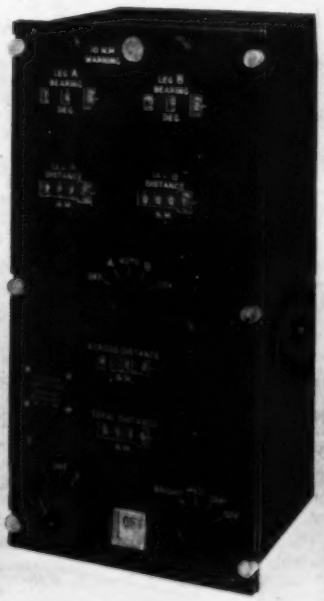
In Britain, there are two civil Dopplers, the Marconi AD.2300 and the Decca Radar Type 61. The latter is, in fact, a straightforward unit for civil or certain military uses and a version of this is intended for combination with Decca and Dectra in DIAN. Decca type 60 is a comprehensive military Doppler. A self-coherent, pulsed janus system is employed with an aerial consisting of sixteen slotted waveguides. The receiver is inhibited during pulse transmissions. Pitch stabilization up to ±20deg is applied to the aerial. The tracker and computer are transistorized and the basic Doppler weighs 65 lb. Output may be either in the form of meter indications or on a Flight Log, the latter being used whether Decca is included in the equipment or not. Performance, racking and distribution of the units is in accordance with ARINC specifications. Decca have more than three years' experience with military Doppler and trials of the civil equipment are now under way.

The Marconi AD.2300 with a computer was extensively demonstrated in a Viking early last year. The Doppler element alone weighs less than 100 lb and the aerial is small enough for installation in the wing of an airliner. Of the three versions available, the AD.2300A is a straightforward Doppler, the AD.2300B includes a simplified computer and the AD.2300C has a comprehensive computer with such facilities as automatic calculation of magnetic variation and computation of E.T.A. Racking complies with ARINC standards. The FM/CW transmissions emanate from an aerial consisting of four slotted, linear waveguides, two used for reception and two for transmission. Mechanical switching is used for alternating the beams; and phonic-wheel discriminators are used in the tracker to derive the Doppler frequencies. AD.2300 is now being evaluated in airline service.

Doppler now offers accuracies which will result in positional errors of the order of a score of miles at the end of an Atlantic crossing, even without corrections derived from fixes with other aids en route. Its future in airline service therefore seems assured.



The slotted waveguide planar array of the aerial for the Decca Radar Doppler (below). It is pitch-stabilized and swivels to measure drift



Left, the control and indicator panel of the Marconi AD.2300B Doppler. Below, the indicator dial of the Computing Devices of Canada Skyline computer used with the Bendix Doppler

FLYING AIDS . . .

An over-the-shoulder view of a "hands-off" automatic approach in a B.L.E.U. Varsity at R.A.E. Bedford. The runway can be seen through the circular windscreen panel

PRECISION FLIGHT

Trends in Flight Control Systems

ALL the new transport aircraft carry an autopilot and most of them also have some form of integrated flight instrumentation either working from the same references or designed to provide an independent monitoring facility for those references. In any future transport aircraft it is highly probable that the autopilot and flight controls will themselves be integrated.

Coupling of the autopilot to the I.L.S. receivers is now virtually standard, so that automatic approaches, with or without automatic control of throttles, are a common procedure. In this way an airliner can be brought down to a height of about 200ft wherever the I.L.S. transmissions are not excessively affected by terrain conditions. The minimum approach height of 200ft is dictated by two principal factors. Firstly, the basic limitations of present I.L.S. installations are such that their guidance in azimuth and, more particularly, in glide-path is not sufficiently accurate below heights of this order. Secondly, if the pilot is to make a visual touch-down, he will require most of the time taken to descend the last 200ft to recognize and align himself with the visual aids and to make the actual round-out and touch-down.

One of the shortcomings of present lighting patterns is that they give insufficient glide-path guidance. Conventional angle-of-approach indicator lights, using single lamps with red, orange and green segments, have never proved satisfactory, although a much more powerful and elaborate example produced by the General Electric Co. Ltd. was extensively tested at Blackbushe some time ago. Two further systems were evaluated by R.A.E. during last year. One was the Australian Cumming/Lane System consisting of two wing-bars of lights, one close to the ground and the other elevated on poles, their relative heights being adjusted to define a given glide-path angle when viewed in line with each other. The other was developed by R.A.E. and consisted of bars of light about 30ft wide, spaced at the fore and aft limits of the correct touch-down area. The bars were formed by powerful lamps, half of whose reflector area was covered by red lenses. The lamps and lenses were set within shallow boxes with both the red and white light rays emerging through slits cut in the box-ends. Each box was then tilted so that the pink intermediate light defined a three-degree glide-slope. Two parallel three-degree slopes thus bracketed the correct approach path. If the aircraft was low, both pairs of bars would show red; if it approached high, both would be white. Ideally the nearer bar showed red and the further white. Extremely accurate guidance was given right down to touchdown and the bars also gave some bank reference. Visual range was considered to be at least two miles by day and 8 to 10 miles by night. This system has been installed at Blackbushe, Aberdeen, Prestwick, Belfast and Liverpool.

The limitations in accuracy in the present I.L.S. can be reduced considerably by redesigning the existing aerial systems in order to eliminate the distortions caused by reflection from terrain and buildings. In the resulting trend to make the localizer transmitter directional, the Pye I.L.S., which has been standardized for the R.A.F. and installed at many European airfields, can be considered the first stage. It uses a parabolic reflector which renders the beam effectively uni-directional, but does not wholly concentrate transmitted energy in a narrow sector. Pye I.L.S. conforms to I.C.A.O. standards and installations are likely to be made at Prague, Moscow and Kiev.

More recent developments both in Britain and America have produced localizer radiations limited to a 10 deg arc about the centreline. Parabolic reflectors, linear dipole arrays and slotted waveguides have been used. Although the narrowing of the coverage is not necessarily desirable because the ability to make a curved instrument approach may be required in the future, it does avoid those reflections from ground features which cause irregularities. But the use of a narrow localizer might eliminate interference between neighbouring I.L.S. installations and make the use of single universal I.L.S. frequency possible. Similar refinements can be applied to the glide-slope aerials and one directional installation in America consists of a pair of aerials mounted close to the ground alongside the runway. A remarkable improvement has resulted in glide-path accuracy, even in areas where terrain conditions previously made provision of any glide-path at all virtually impossible.

Localizer aerials which project some distance above ground cannot be mounted on the centreline close to the end of a runway and glide-path aerials similarly have to be positioned at least 400ft to one side. The next stage in development has therefore been to mount the aerials flush with the ground, either buried in the runway surface or laid out beside it. Such systems are effective, but would be very costly to install. Both localizer and glide-path radiation patterns would be confined to a given azimuth arc and they would not use the ground as part of the aerial system. An arrangement has been proposed by R.A.E. in which the glide-path aerial would consist of two flush, linear aerials buried parallel to the runway, one of them 45ft long and the other 200ft. The localizer array, also flush, would be set midway along the runway, to cover both landing directions, in the form of three rows of nine strips, each 18ft long and spaced at 18ft intervals down the runway. Each row would cover 40ft of the width of the runway.

With improved I.L.S. aerials of this type it can be foreseen that the minimum height for accurate I.L.S. guidance might be reduced to as little as 50ft.

Last month, Standard Telephones and Cables Ltd. issued a preliminary description of the STAN.7-8 I.L.S. system which is based on the mobile AN/MRN-7-8 produced by Federal Telephone and Radio Co. The British equipment is designed for permanent installation, but is functionally equivalent to MRN-7-8 and complies with I.C.A.O. standard requirements. The localizer is defined by a linear dipole array 85ft wide and 12ft high, called the course aerial, which produces a directional localizer reference over an 18 deg arc. Behind it is another, smaller array called a clearance aerial which radiates a second localizer pattern over the whole 360 deg with a carrier frequency 9.5 kc/s different from that of the course array. The latter is unlikely to be disturbed by ground reflections and its secondary lobes will be masked by the radiation from the clearance aerial. The airborne receiver will easily receive both radiations, but will naturally suppress one where the course-aerial radiation predominates. The glide-path aerial consists of two wide-band dipoles mounted on a common mast in conventional fashion. The whole equipment is self-monitoring and automatically changes over from main to standby transmitters if distortion or fault occurs. Marker beacons are also provided.

In bridging the gap between automatic approach and automatic touch-down a number of basic techniques have to be considered. Many of them have already been tried and sufficient landings made to allow a statistical assessment of landing probability. The first requirement is for an autopilot which can give the necessary automatic control. In case of autopilot runaway it is extremely unlikely that the pilot will be able to avert disaster by taking over manually at any height below about 60ft. His intervention must therefore be excluded at this critical stage. With the single-channel autopilot now used at the R.A.E. Blind Landing Experimental Unit the probability of an incident during the landing manoeuvre is about 4 in 100,000 landings. A built-in monitor

will help in detecting faults and disengaging the autopilot, but cannot correct some of the faults which may occur. As a next step, a duplicate autopilot could be set to cut out automatic control if a discrepancy arose between the two, but the probability of this occurring is 7 in 100,000 landings, which is comparable with the error probability of the human pilot. Automatic disengagement in the final stages would in any case leave the pilot in a difficult situation.

A triplex system with three parallel channels can be set so that a deviation in one will cause it to be cut out, leaving the other two in control without any disturbance in the flight path. To ensure that the triplex system is working before starting the approach, either a quadruplex autopilot or a triplex autopilot with spare units would be needed. Probability of incident with the triplex system is about 3 per thousand million landings. A triplex three-axis unit might weigh 196 lb before installation and a quadruplex, three-axis unit 235 lb.

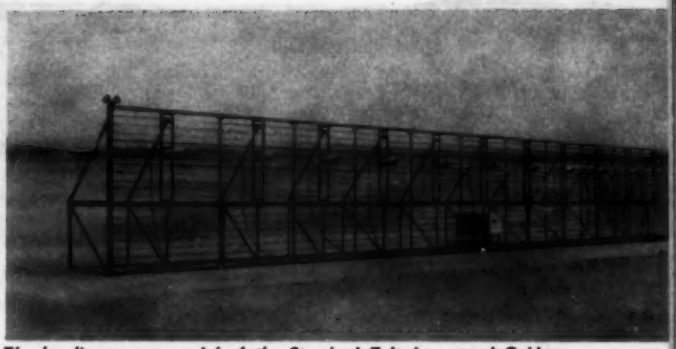
An automatic landing system may either have the main control system on the ground or in the aircraft under direct supervision of the crew. The latter is more likely to find favour with pilots, and it would allow the airline to supervise the serviceability of its own equipment without relying entirely on airport authorities. In an airborne system the pilot could either monitor operation through instruments deriving information from the automatic system itself or he might have an entirely independent system for monitoring. Multiple-channel autopilots would be applicable in either case.

A typical example of the ground-based autolanding system is the Bell Aircraft A.L.S., originally designed for the U.S. Navy, with which 100 landings were made aboard *Antietam* in the Gulf of Mexico by an F3D Skyknight in the autumn of 1957. More than 2,000 automatic landings have now been made on many airfields with such aircraft as Dakotas, B-47s, the Boeing 707 prototype and a Regulus 2. Runway touch-downs have shown a longitudinal dispersion of only 18ft. Trials with a B-47 were carried out at Dobbins A.F.B. last December. The system has been evaluated by the R.C.A.F., PanAm, K.L.M., B.O.A.C. and Lufthansa.

Bell A.L.S. has a radar which locks-on to the aircraft at a theoretical "gate" 4 miles from touchdown, at a point when the aircraft is under control of the autopilot coupled to an I.L.S. frequency modulated by pitch and bank commands from the ground. The warning flags will appear in the cross-pointer indicator when lock-on occurs and the pilot can monitor operations with a second I.L.S. receiver if I.L.S. and A.L.S. glide-paths coincide. Glide-path coupling is partly disabled at lock-on. Lateral control from the ground will begin immediately, but pitch control will remain under autopilot control until the glide-path is reached. At the point of round-out, the height-command path levels off and the nose of the aircraft is raised by a pre-computed amount to effect touch-down at a rate of descent of 2ft/sec. A few seconds before this, a signal is sent to allow the pilot or autopilot to "decrab" (kick off drift). If radar lock-on is lost during the approach, the command transmitter is automatically switched off to order a "wave-off." After touch-down, when radar lock-on is lost as the aircraft passes outside the scanned area, the resulting wave-off signal is disabled and subsequent commands stored to prevent any transients occurring.

Early during the approach, guidance sensitivity is low, but it increases linearly to remain constantly high after the aircraft is within 4,000ft of touch-down. At the four-mile "gate" an aircraft may be at most one mile off centreline and 60 deg off heading. The height element of the gate is at 800ft, but may be altered to suit glide-path angles of from one to 14 deg. With two radars in use and a four-mile "gate," aircraft with an average approach speed of 120 kt may be landed at the rate of one per minute. This could be doubled by setting the "gate" at 2 miles, but initial positioning would have to be more precise.

No climb signal will be transmitted before the glide-path is reached and any pitch commands beyond specified limits will cause a wave-off. Maximum bank-command signals are limited as a function of range, and never exceed those required to achieve a rate one turn. By touch-down, limiting bank-command is virtually zero. Centreline-closing angles are progressively reduced from 40 deg at long ranges to nine deg at about 4,000ft from touch-down. When several aircraft are approaching using a duplicated installation, a special circuit computes whether one might overtake the other. The beginning of flare-out and decrab stages are signalled in the cockpit. A standby data link could be superimposed as a sub-carrier modulation on a communications frequency with minor modification of the appropriate receiver. In extreme cases a voice talk-down could be given.



The localizer course aerial of the Standard Telephones and Cables STAN.7-8 I.L.S. system. This aerial transmits over an 18 deg sector

The Bell A.L.S. is mobile and accommodated in trailers. The different approach characteristics of various aircraft types can be stored and quickly fed into the computer. A further system being developed for the U.S.A.F. incorporates a radar which will track signals transmitted from the aircraft. Commands will be superimposed on the tracking channel.

A typical airborne system is that developed by the Blind Landing Experimental Unit at R.A.E. over recent years and first publicly demonstrated last October (*Flight* for October 17). The B.L.E.U. system is based on a Smiths S.E.P.2 autopilot, Standard Telephones and Cables radio altimeter STR.30B, Murphy leader cable and Pye I.L.S. Some 2,000 successful automatic landings have been made with Varsities, Devons and Canberra T.4s and the system is ready for engineering to airline requirements. It is based on equipment which is largely already in service. A special throttle-control system was developed by Smiths to control engine power according to A.S.I.-error and attitude-demand signals. Very little "tailoring" would be needed to make the system fit a wide variety of aircraft types.

The writer flew through several automatic landings in a Canberra T.4 at R.A.E. and noted touch-down at a rate of descent of about 1ft/sec within 30ft of the designated point each time. He particularly noticed the smooth control throughout and the ease of operation, describing it as follows:—

"A B.L.E.U. automatic landing is divided into phases called track, glide, leader cable, attitude, flare-out, drift correction, touch-down and ground run. First, the aircraft is set to fly at about 1,000ft on autopilot, using barometric height lock. A turn is made and the track control operated to initiate I.L.S. localizer capture. The aircraft settles on the beam and comes up to the glide-path, as indicated by the I.L.S. horizontal pointer. The throttles are automatically controlled to give a pre-selected approach speed with wheels and flaps down.

"Still following standard automatic-approach practice, the pilot selects glide-path to the autopilot and at any moment from here down to a height of 600ft he may prime his automatics and elect to make an

The Boeing 707 prototype being landed with the Bell ground-based automatic landing system at Boeing Field, Seattle. The radar aerial and computer caravan are in the foreground

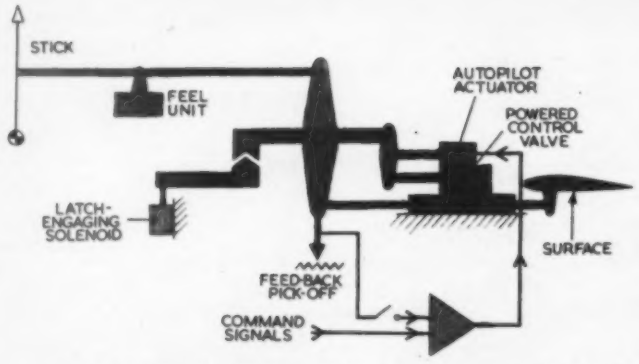


Fig. 1. Suggested Sperry system for an integrated control system for use with an autopilot

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automatic landing. He has 1½ min in which to decide. The radio altimeter begins to read at 500ft above ground (if it is inadvertently left in the 0-5,000ft range it automatically reverts to 0-500ft). At 300ft, leader cable automatically takes over azimuth guidance from I.L.S. localizer. Glide-path and automatic throttle continue working, but leader cable signals now control the relevant indications on the Flight System instruments.

"At 100ft the radio altimeter automatically disconnects glide-path guidance and for the next 5 sec or so the pilot maintains the attitude which has been averaged for that approach. At 50ft the aircraft is over the runway and the radio altimeter supplies rate signals to control an asymptotic flare-out, while power is automatically progressively reduced to flight idle. At 20ft, leader cable is discarded and the autopilot kicks off the difference between runway heading manually set on the beam compass and course held to counteract drift, at the same time holding the wings precisely level. Flare-out completed, the aircraft touches down at idling power and automatics are switched off. The pilot then follows visual leader-cable and compass information presented on the Flight System instruments and brakes the aircraft to a standstill. Actual touch-down velocity can be adjusted by re-programming either the throttling-back sequence or the flare-out. The main considerations are that the aircraft should make a positive arrival near the desired point without either landing too hard or floating too far.

"The system can be disengaged at any time by releasing the autopilot and progress to each stage is shown by illumination of successive segments of a green-lit indicator dial. This is the only extra dial on the panel."

B.L.E.U. felt that some completely independent means of checking automatic performance might be required, and work is progressing on Televiewer, in which a series of radio beacons along the runway transmit a TV picture equivalent to direct sight of runway lighting on to a screen in front of the pilot. To assess parameters for this a closed-circuit TV camera was mounted in the nose of a Devon and then in a Meteor "7/8/9." Night landings showed the required field of view and definition for an approach at 135 kt as ±13 deg in azimuth and ±10 deg in elevation with a definition of 10 min of arc. The lower limit was 50 min of arc. A 1 : 1 magnification ratio was used. Televiewer might form a pilot-operated automatic landing system in its own right.

The very high positional accuracy of the Decca Navigator system might well also be applied to automatic landing. It is probable that special, low-power master and slave stations sited at a given distance on either side of a runway could produce an accurate hyperbolic pattern of which one lane would define the runway centre-line. Addition of a third station could logically provide a ranging pattern and all the signals could be computed to produce centreline, distance and required height indications. The system could be mobile and be set up at an airfield without need for preliminary calibration.

Precision approach radar has not been mentioned in this survey of approach techniques, but its usefulness for monitoring any kind of automatic approach or landing is self-evident. It would additionally provide primary approach-control at an airfield where the more ambitious systems are not available. Particular examples of British P.A.R.s are the Standard Telephones SLA.3 (described in *Flight* for November 21 last year), the Decca Radar type 424 and the Cossor A.C.R.7C. Ekco Electronics have also produced an ingenious simplified combination of tracking radar and V.H.F./D.F. for use at small airports.

Advanced new autocontrol/instrument installations are now being actively developed for the larger and faster aircraft. The present trend for these is to separate sensing and display functions, as exemplified by air data systems and remote gyro references. The sensing instruments then provide for indirect display (for example in the flight director) and automatic control, resulting in more accurate information and improved displays.

Most aircraft in this class nowadays have powered controls, and the trend is to feed autopilot and autostabilizer signals directly to the powered control actuator, thereby saving weight and complication and also improving response. One method proposed by Sperry for this purpose is shown in Fig. 1. Autopilot or autostabilizer signals are here fed to a miniature actuator, the work of which is limited to operating the powered control valve. For manual control the error point is unlocked and, if no signals are fed to the autopilot actuator, the latter remains stationary and the system works like an ordinary powered control. For autostabilization, signals are fed to the autopilot actuator and no feedback is taken; movements of the autopilot actuator must then be cancelled by mechanical feedback from the jack, which moves by the required amount, limited by the autopilot actuator travel, without reflecting autostabilizer movements in the control column or rudder pedals. In the autopilot mode, the latch is engaged by a spring, and control demands are cancelled by electrical feedback from the jack, which then moves the stick through the linkage. Artificial feel loads are reacted by the latch and, if these exceed a preset value, the latch is pushed out, the error point then moving and reinstating mechanical feedback. The control cannot then go any further, being held by the feel spring. Similarly, the pilot can overpower the autopilot by exerting enough load to move the latch out of engagement. This system is expected to provide more accurate and reliable torque limitation than has been possible in the past with non-integrated autopilots.

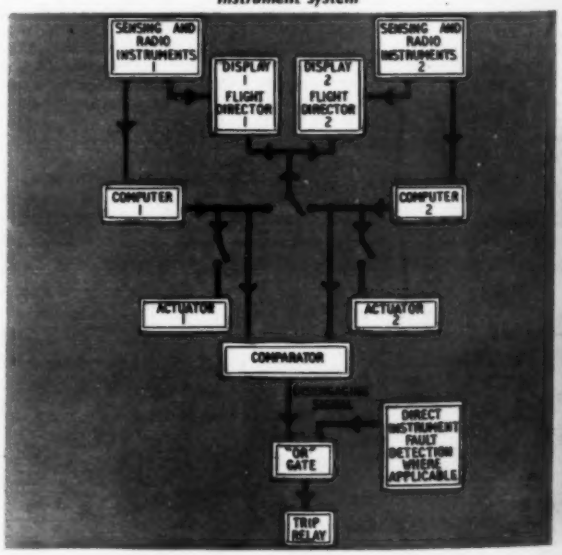
On large airliners, flight instruments and radio aids are at least duplicated. There is a trend to duplicate the autopilot as well, and perhaps even to triplicate or quadruplicate those portions of it which are concerned with automatic landing. Duplication may be by parallel channels, the sound channel holding the runaway one in case of fault, or by alternate channels, the alternate channel monitoring the other and disengaging it in case of fault. The actuating system of Fig. 1 lends itself well to the "alternate" type of duplication if the aircraft has divided surface-controls. The two channels would operate different surface sections in each control axis. The section under autopilot control drives the remaining sections through the mechanical linkage.

A recent Sperry project on this basis (illustrated in Fig. 2) shows how such a system may be made to work without involving much additional equipment as compared with an unduplicated system.

The system in question is based on two identical computers of which usually No. 1 controls the autopilot and No. 2 the flight director, so that no additional computer is involved. Data are derived from instruments and radio aids which are duplicated in any event. If a fault occurs, the faulty computer is switched off automatically or manually, and the remaining computer can be made to operate the autopilot or flight director as desired. This system has the further advantage that a single control panel applicable to both autopilot and flight director can be provided. When a channel selector included in the panel is in the "normal" setting, selection of autopilot control leaves the flight director engaged. The flight mode selected with the appropriate controls will apply to autopilot or flight director, or both, as required.

Automatic disengagement is based either on certain directly detectable instrument faults, or on discrepancy between Nos. 1 and 2 computers, *plus* the existence of a minimum manoeuvre. Unnecessary disengagement of the autopilot if No. 2 computer develops a fault is thus avoided. Manoeuvre-detection is performed by rate gyros and accelerometers.

Fig. 2. Schematic layout of a paralleled, self-monitoring autopilot/instrument system



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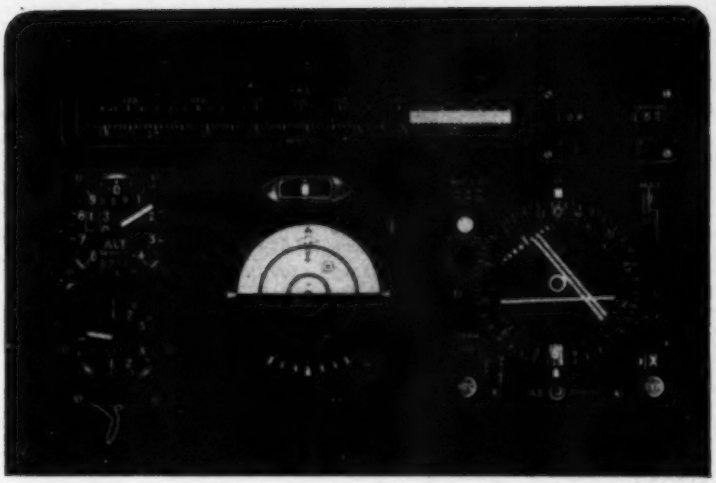


The Kelvin Hughes Flight Data System panel, incorporating a tape indicator for speeds, dial instruments for height and vertical rate, roller-blind horizon with slip ball, and compass/navigation display here set for I.L.S. The steering-command ring and the symbol indicating vertical upward flight on the attitude indicator are not in realistic relationship

INSTRUMENTS

Improved Displays Involve Weight and Complexity

SEVERAL years ago it was said that dial instruments with rotating pointers belonged to the "clock age" and were hopelessly out of date even for aircraft of the immediate future. The theory was that a circular scale was not the right presentation for a quantity which was, from the pilot's point of view, linear. The background to this new approach was the development of tape indicators for height, rate of change of height, speed and Mach number. Height could be shown on a tape system set vertically to provide an almost pictorial indication. Speed values, similarly, were to be shown on horizontal tapes. The roller blind, in itself an extension of the tape, provided at once the ability to follow a looping manœuvre on a continuous indicating surface and the possibility of printing several displays on one length of blind and thereby rapidly replacing one type of information with another in a single dial. In attitude and navigation displays, the roller-blind assembly could be conveniently rotated to present roll and heading indications respectively.

Since the conventional capsule and gyro movements could no longer provide the extent of displacement and the power needed for this type of display, remote sensing elements were introduced in the form of air data computers and master reference gyros. The integrated blind-flying panel which resulted was evaluated in a Meteor and, by all accounts, provided a full and effective reference for controlled aerobatics in cloud. The original requirement had been for an all-attitude instrument system which would make it possible for a pilot to fly a prolonged vertical climb and then level out on a given heading by pulling over into the inverted attitude and rolling level.

Both in Britain and America, development of tape instruments has continued and such aircraft as the Convair F-106 are to be fitted with the American system in the near future. In Britain, the master reference gyro, made by S. G. Brown Ltd., has been introduced into all the latest high-performance aircraft and the Kelvin Hughes panel probably accompanies it in many installations. But some of the inherent difficulties have led to the replacement in this panel of tape indicators for height and rate of change of height by conventional dial instruments. It is difficult to provide accurate indications on a tape which is not excessively long. On a manageable length of tape, the smallest units cover too short a distance to be accurately discerned by the pilot. A moving pointer traversing a short scale will equally give only coarse indications.

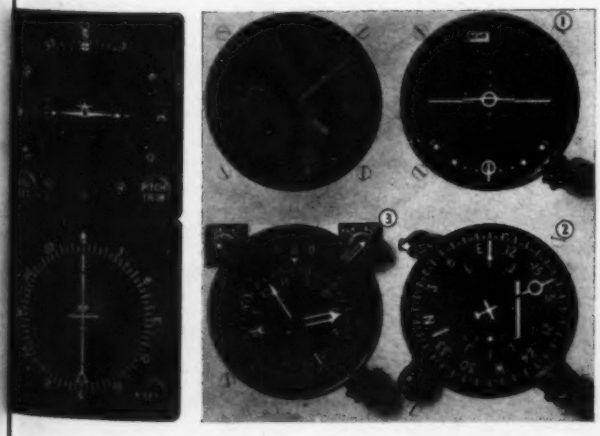
In airliners, the tape instruments have not been adopted, if only because of the basic alterations required in the whole panel layout and particularly because of the additional equipment needed to support the system. The Services learnt the bitter lesson of the shortcomings of dial altimeters many years ago, and now civil operators have been caught out in their turn and have the same lesson to learn. A number of recent accidents to airliners which consistently cruise at over 10,000ft have been tentatively attributed to a misreading of the conventional altimeter. Several palliatives can be incorporated in conventional capsule-driven instruments in the form of warning flags and additional indicator segments, but none of these seems to offer a completely effective solution to the problem. The veeder counter instrument may be unequivocal in its indication, but it requires servo operation and is hardly more pictorial than the dial. It seems inevitable that the additional complexity, cost and weight of the remote-indicating systems with their additional power for long-scale drives will have to be accepted fairly soon.

The six-dial panel which became standard during and after World War 2 is recognized as containing much information of a basic kind which requires correlation and interpretation by the pilot. The introduction of the Sperry Zero Reader and then the combination of this type of director display with attitude and heading information in integrated systems has produced a marked improvement in the information which can be directly derived from the blind-flying panel. These newer instrument groups, examples of which are currently produced by Smiths in Britain and Sperry, Bendix, Lear and Collins in America, have become an important feature of airliner cockpits. Automatic approaches with autopilot couplers are now a routine and important feature of airliner operations. But the more complicated the presentation, the harder it is to detect malfunctioning, and redundant indicators may remain in view when the director elements are not in use.

Nevertheless, the flight director systems do provide an excellent means of monitoring the performance of an autopilot coupled to V.O.R. or I.L.S.

It has long been traditional to indicate attitude on the artificial horizon by means of a horizon bar moving in relation to a fixed aircraft symbol. The mechanical linkages in this type of presentation are relatively simple and the method was universally accepted. Further studies carried out during recent years seem to indicate that the opposite method was, in fact, better and that a moving aircraft symbol should be portrayed in relation to a fixed horizon defined either by a white reference line or a straight border between two zones of different colours, white for sky, black for ground or blue for sky and green or brown for ground. A compromise between these two methods was suggested by a Convair engineer and incorporated in an integrated display called Kinalog, described in *Flight* for November 28, 1958. Both horizon and

Below right, the three instruments of the Smiths Flight System with an A.S.I. the altimeter and V.S.I. would be positioned to the right. Below left, the two instruments of the Lear Integrated Flight Equipment (LIFE). The aircraft silhouette on the attitude indicator moves in relation to a fixed horizon reference. The small diamonds like tip-tanks are the pitch-command symbols



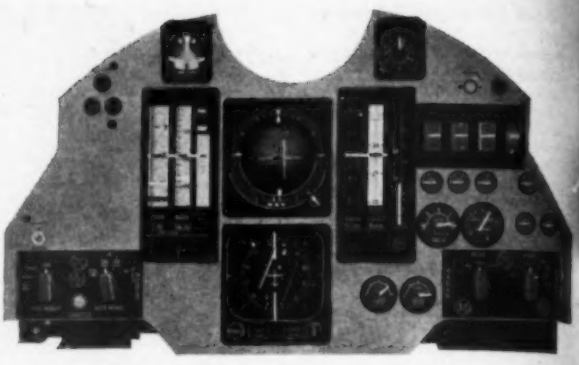
FLYING AIDS . . .

aircraft symbol moved in the Kinalog system, first in the new sense and then in the traditional sense as a turn or climb was initiated and then held stable.

It has long been the dream of the instrument engineers to combine the conventional heading indication with a pictorial map to show the pilot not only which way he is flying but where he is. Innumerable difficulties stand in the way of such a system, not the least of which is that of providing sufficient flexibility to cover an adequate operating area, without filling the cockpit with map, and to find some method of navigation which will give an accurate indication of ground position.

It is certain that no considerable advance in the quality and quantity of instrument information provided will be obtained without the addition of a considerable weight and volume of complex and sensitive equipment. This factor alone weighs heavily against any integrated system since reliability is as important in instruments as in any other part of the aircraft. Already, the introduction of relatively limited integration and director functions has led to an extensive range of miniature stand-by instruments of traditional kinds in order to allow for any failure in the primary system. Thus, the space saved on the panel by integration is often more than taken over by stand-by instruments. The remote gyro and air-data references already occupy additional space elsewhere in the airframe and require suitable power supplies and other services. Miniaturization and extreme reliability are therefore prime requirements.

During the last eighteen months, the considerable amount of information released in America on the Army-Navy Instrumentation Programme, for which Douglas El Segundo and Bell Helicopter are respectively co-ordinating fixed wing and helicopter applications, has shown that the way towards a radically new form of blind-flying and navigation instrumentation is by no means clear. Transparent, flat television tubes mounted in way of the windscreen and combined with various kinds of map

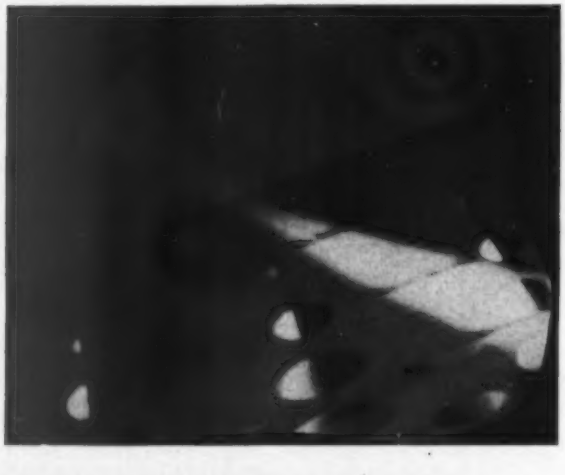


The U.S.A.F. instrument panel to be incorporated in F-106s and F-105s. Plan-position and attitude-command instruments supplied from remote sensors are flanked by tape indicators for speed and height values

display have taken many forms. In the first instance, an attitude and movement display in the form of a mobile grid reference was presented on the television tube. Then a track and manœuvre-guidance system called Pathway was added. No final result is expected before the early 1960s.

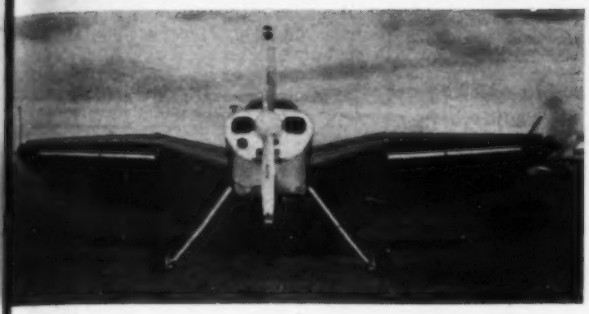
A remarkable development has been the Sperry inertial system designed to provide both instrumentation and automatic navigation for the North American X-15 research aircraft. Because this machine will fly to some extent in regions where the atmospheric density is insufficient to feed normal pressure-sensing systems, the inertial reference, composed of a three-gyro platform with three integrating accelerometers, will supply height, rate of change of height, speed, attitude, heading and positional information. Three of the instruments with their very simple scales and broad indicator needles are shown below. The inertial platform is Schuler-tuned to remain continuously aligned with the local vertical and will initially be monitored and zeroed from a control panel inside the B-52 mother aircraft. Velocity signals derived from an APN-81 Doppler and the B-52's compass system, with the addition of height information derived from the B-52's pressure sensing system and from ground-based radar will all be fed into the X-15's inertial system while the two aircraft are preparing to separate. The platform gyros will be run up immediately after take-off and their performance monitored before separation. After the X-15 begins its free flight the inertial system will function without any further external reference. The whole complex is first being installed in an F-101 for trials and the first system for the X-15 itself was delivered last December.

It is by no means safe to say that the dial instrument has had its day; nor can it yet be claimed that the tape indicator is a fully effective answer to the shortcomings of dials. There seems to be no doubt that the inevitable penalty of providing suitable display configurations and properly accurate information will be greatly increased complexity of equipment and almost entirely remote indication by means of servos and synchros. What the human eye sees through the windscreen on a clear sunny day will not, for some years to come, be pictorially reproduced without penalties of weight and complexity.



Above left, the Pathway track-guidance system on the television attitude display of one of the ANIP schemes. Below left, the Schuler-tuned, three-gyro stable platform made by Sperry for the navigation and instrument system of the X-15. Below are the indicators for inertial speed (ft/sec x 1,000), vertical rate (ft/sec x 100) and height (100,000ft and 10,000ft needles)

A new U.S. approach to STOL: the Paraplane Commuter 110 produced by Lanier Aircraft Corporation as a light private and business aircraft with exceptional slow-flying performance. The machine is reported to have a speed range from 15 m.p.h. to 165 m.p.h., and a take-off distance of only 20 yd



PARAPLANE COMMUTER 110 is the name of the new STOL light aircraft illustrated above, which is intended as a safe, low-cost business and personal machine. Stated to have a speed range from 15 to 165 m.p.h. and a take-off distance of only 20 yd, the aircraft was designed and built over the past four years by Lanier Aircraft Corporation of Newark, Moorestown and Marlton, New Jersey. The prototype flew for the first time a few months ago.

According to Edward M. Lanier, president of the Lanier company, "Due to its patented design and patented devices known as Vacu-jets, which offer safety through advanced aerodynamics, not highly skilled piloting, the Paraplane is given a stall-free and parachutic effect when desired and simulates the steep safe landing of a parachute in very little area. Therefore, Paraplanes can be landed onto and flown out of areas that were previously limited to helicopters only. The angle as well as the rate of climb is very much greater than that of conventional aircraft."

The five main advantages which the makers claim for the Paraplane are: (1) inherent safety, with better anti-stall and anti-spin qualities than other aircraft; (2) manœuvrability, especially at very low speeds; (3) utility (because of the much slower take-off and landing speeds the need to use airports is eliminated, and the short wingspan adds to the ease of hangaring and ground operations); (4) the speed per unit of engine power is as good as or better than that of conventional aircraft in similar categories, and is much greater than that of the helicopter; and (5) the manufacturing cost of the Paraplane is low (price ranges being $5,000-$9,000 for single-seater and two-seater versions, and $8,000-$12,000 for four-seater).

With a span of 20ft 7in and length of 21ft, the single-seat Paraplane Commuter 110 carries a useful load of 500 lb at a normal gross weight of 1,280 lb. The machine is powered by a Lycoming O-320 of 150 h.p., driving a McCauley fixed-pitch metal propeller. Normal fuel tankage is 24 gal carried in the wings; for ferrying, an extra 20 gal can also be carried in built-in wing-tanks, at an aircraft gross weight of 1,400 lb. Flaps, "flaperons" and the boundary-layer control device known as the Vacu-jet are fitted.

Performance figures for the single-seat version include: maximum speed, 165 m.p.h.; cruising speed, 151 m.p.h.; range with 45 min fuel reserve, 625 miles; take-off and landing speeds, under 30 m.p.h.; take-off and landing distance, 20 yd; rate of climb, 1,500ft/min; distance to 50ft, 55 yd; slow-flight speed with good control, 25 m.p.h.; slow-flight speed without loss of height, 15 m.p.h.; ceiling, 23,000ft. A four-seat version powered by a 180 h.p. Lycoming, and with a gross weight of 2,200 lb, is planned.

Sport and Business

AN INTERNATIONAL GLIDER TRADE FAIR, run by the British Gliding Association, is to be held at Lasham during the first two or three days of this year's National Gliding Championships. British and foreign manufacturers of gliders and glider equipment are being invited to participate, and Lasham's new hangar will be used as an exhibition hall for the occasion. Foreign sailplanes which will be flying at Lasham during the nationals week will, it is hoped, include French, Polish and Czechoslovak machines. If successful, the trade fair may become a regular part of the championships programme.

A SALES WEEKEND at Kidlington Airport, Oxford, is to be held for the second time by W. S. Shackleton Ltd. this year. The meeting, which will take place on April 24th, 25th and 26th, will include new aircraft, both European and American, in addition to a wide selection of secondhand machines. The company states that invitations to exhibit aircraft have already been accepted by the leading U.S. manufacturers and several European companies.

THE DUKE OF BEDFORD is planning a national air rally at Woburn Park on May 2. A new airstrip has recently been completed there, and assistance is being given in the organization of the event by the Royal Aero Club.

Making their second move in five years, members of the Surrey Flying Club transferred from Croydon to Biggin Hill on February 8. The photographs below show clubhouse chairs being loaded at Croydon (left) and the piano being moved into the new accommodation at Biggin

"Flight" photographs

Straight and Level

ON the eve of the Government's long - awaited announcement about the R.A.F.'s new strategic transport, Sir John Blackout-Jones, firebrand chairman of Scruggs Aircraft, called a news conference in London.

"The way I see it," said Sir John, as a posse of 12 Scruggs brochure-bearers staggered laden into the conference, "the choice lies between half-a-dozen contenders. Obviously it would be ridiculous"—Sir John almost choked with mirth at this point—"for the R.A.F. to have two or three of each type competing for the order. So the only sensible alternative is for the Government to finance, and the R.A.F. to buy, an entirely new project which combines the technical and political merits of all the contenders."

His staff then handed each member of the Press a copy of the brochure, which was entitled *Scruggs—World Leaders in Economic Air Warfare*. The brochure gave the following details of a new Scruggs project:—

Scruggs S.A.491 Warmaster: Jet and turboprop power by Burstmore Aero-engines Ltd., thus combining "the best of both worlds of propulsion." Aft-loading, side-loading, ventral-loading, dorsal-loading, front-loading, wing-loading and ability to carry 78.5 tons of equipment for 7,813 miles at a speed of 687 m.p.h., using 2,000ft airstrips. Delivery in 1960, price £250,000 each.

COURT AND SOCIAL

The merger announced between Scruggs Aircraft Ltd. of Plane Works Road, East Sheen, and Burstmore Aero-Engines Ltd. of Twitchington Manor, Essex, will not now take place.

● "*That* independent airline—huh! Nothing but a shower of stunt-merchants, with an overdraft as red as your eyeballs. I tell you, old boy, we're not worried by those buccaneers."

Who said that? A senior executive of another independent airline. I am all for independent rivalry, but there is no room for backbiting in an industry fighting for the same things.

● Quote from *Bendix International News Reporter:*—

"A man lived by the side of the road and sold hot dogs. He was hard of hearing so he had no radio. He had trouble with his eyes so he read no newspapers. But he sold good hot dogs. He put up a sign on the highway telling how good they were. He stood by the side of the road and cried 'Buy a hot dog, Mister.'

"And people bought. He increased his meat and bun orders. He bought a bigger stove to take care of his trade. He got his son home from college to help him. But then something happened. . . . His son said, 'Father, haven't you been listening to the radio? There's a big depression on. The European situation is terrible. The domestic situation is worse.'

"So his father cut down on his meat and bun orders, took down his advertising signs, and no longer bothered to stand on the highway to sell hot dogs. And his hot dog sales fell almost overnight.

"'You're right, son,' the father said to the boy. 'We are certainly in the middle of a great depression.'"

There may be something in this fable. On the other hand, the airlines have been selling their capacity ton-mile hot-dogs hard right throughout the recent recession. But, as the load-factor figures show, people haven't been buying much more than half.

"I just wanted to watch the planes," 70-year-old Mr. Andrew Bird said at Cleveland Airport on February 5, as he was explaining how his car came by its new sunshine roof. Mr. Bird had allegedly just driven the whole length of the runway and back, passing *en route* between the propellers of a four-engine U.S.A.F. transport warming up for take-off." I guess I took the wrong turning," Mr. Bird—who escaped injury—is reported to have said

● Straight and Level is pleased to announce the purchase of an Air Trumpet from Thinx Electronics Ltd. The version actually supplied will differ from the standard model: the volume control—which normally limits output to 350 db—will have an override to permit short bursts of up to 400 db.

This should give added emphasis to an important, and often overlooked, aspect of the Decca v. Vortac controversy between America and Britain. My adviser on air navigation, Dr. Homer Beamish, will attend the next I.C.A.O. air navigation meeting carrying the Air Trumpet, and at an appropriate moment during the proceedings he will arrange for it to deliver, at 400 db, the following message:—

"Twelve thousand American airline pilots have stated their preference, through the International Federation of Airline Pilots Associations, for a pictorial-presentation, area-coverage air navigation aid."

This often overlooked fact means that the world's airline pilots, *including American pilots*, have reservations about Vortac as the long-term answer to the air navigation problem.

The reason why the pilots' preference is not more widely appreciated is probably because they have avoided the use of trade-names, preferring for various reasons to use instead neutral generic terms like "area coverage" and "pictorial presentation."

The result is that the full significance of the pilots' reservations about Vortac has never really struck home.

● The neutrality of trade-names is important politically as well as commercially. I should think twice, for example, about naming a new British aircraft—say—"John Bull."

Brand me as a traitor if you like; but if we want to sell our goods in neutral-country markets we should acknowledge the psychological importance of neutral nomenclature.

● In the military twin-jet v. single-jet squabbling match (this page, Feb. 6) the "single" protagonists make full play with simplicity and aerodynamic cleanness—internal as well as external. They remind me irresistibly of Patrick Stirling, the great locomotive designer of the last century. Stirling was a die-hard defender of the single-wheeler, and when taxed with his conservatism by a proponent of coupled driving wheels he likened the formula to "a laddie runnin' wi' his breeks doon." When it was proposed to fit a new type of external valve gear on one of his beautiful Great Northern singles this same stalwart declared, "I canna spile my grand engine wi' the likes of that machinery ootside of her."

● While on the railroad track I find myself wondering what the boost-glide and Dyna-Soar boffins will have to say about this comment on trains that appeared in the *Quarterly Review* during 1829 (about the time of the Rainhill locomotive contest): "We should as soon expect the people to suffer themselves to be fired off upon one of Congreve's ricochet rockets, as trust themselves at the mercy of such a machine going at such a rate."

● "Police-constable Clifford Cross said yesterday in court at Leeds that while on motor-cycle patrol duty he saw an aircraft flying below him.

"He was at a point 510ft above sea level and he followed the aircraft on his motor cycle and took the registration letters."—*The Times*, February 12.

ROGER BACON

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. Names and addresses of writers, not for publication in detail, must in all cases accompany letters.

Traffic Control: An American View

I HAVE read with interest the article "The Traffic Control Problem," by L. F. E. Coombs, in the December 26 issue of your magazine.

When Mr. Coombs stated that "civil pilots are unanimous in their opinion that any uncontrolled aircraft which is allowed to fly in controlled airspace constitutes a potential hazard," I am sure that he was speaking only for airline pilots and not for the great bulk of other civil pilots throughout the world. To give some idea of comparative figures, using aircraft as a basis, the total airline fleet of the world is some 3,100 aircraft. This may be compared to the U.S. general aviation fleet, which consists of more than 64,000 active aircraft, of which some 6,800 are multi-engined. To look at it another way, the U.S. general aviation fleet flew 10.9 million hours in 1958, as compared with the 3.6 million hours flown by the U.S. domestic airline fleet.

Most of the airspace over the continental United States is fast becoming controlled area, and despite an announced programme of the U.S. scheduled airlines to file I.F.R. for all flights above 10,000ft, we find a tremendous amount of both V.F.R. and I.F.R. flying by their pilots below 10,000ft. Obviously, the U.S. scheduled carriers and thousands of our private and business pilots do not consider that uncontrolled V.F.R. flight in controlled airspace constitutes a hazard.

The U.S. air traffic control system has grown to tremendous size in the past few years both in terms of manpower and in terms of dollars required to keep it operating. The magnitude of their present job may be appreciated after a study of the C.A.A. traffic figures for 1957, which show that their control centres handled approximately 3 million I.F.R. departures. If we double this to include arrivals, we have in round figures approximately 6 million operations. This is about 35 per cent of the seventeen million itinerant operations (both V.F.R. and I.F.R.) handled by C.A.A. control towers. However, the C.A.A. in 1957 operated towers at only 207 locations out of the more than 7,000 airports and airfields shown on their records. Thus the 17 million itinerant operations that their towers reported represent approximately 3 per cent of the nation's landing areas. No accurate figures on nationwide traffic are available, but it is obvious that the 6 million I.F.R. operations handled by C.A.A. control centres in 1957 are only a drop in the bucket of U.S. nationwide traffic. To attempt to control the remainder of this traffic under I.F.R. standards is a task so colossal as to stagger the imagination.

Mr. Coombs's closing recommendation ("the essential need is to get something done well ahead of the next two major phases in aviation: the expansion of jet transport fleets and the intensive use of helicopters and business aircraft in all parts of the world") is indicative of the type of thinking that has effectively prevented extensive use of business aircraft in many parts of the world, including the U.K. It is safe to predict that there will be no intensive use of business aircraft in any country where this school of thought prevails.

Washington, D.C. VICTOR J. KAYNE,
Air Traffic Control Specialist.

Flight-deck Layout

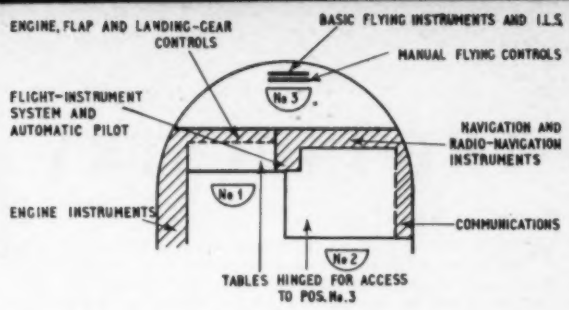
THE presence and experience of a captain approaching retiring age make him one of the most valuable members of the flying profession. Yet, because cockpit convention and layout have not kept pace with operational demands, he may retire too soon rather than attempt one trip too many.

It is more than unfortunate that few flying crew can agree on what is essential in the cockpit. In an endeavour to make an old system fit, more and more instruments and switches are being massed in the front of the aircraft—so many it may need three crew-members to scan them. Space is at a premium, route books are cumbersome, charts are mislaid, and the crew cannot put a cup of tea down anywhere—*yet at the most critical moment of any flight the pilot doing the landing or take-off needs only a yes/no reading or instruction.*

The following outline, to be studied in conjunction with the diagram, is presented as an idea for rationalization in the cockpit. It may be of interest, and possibly of service: —

Objects: (1) To allow captain to command and supervise execution of orders; (2) to make the most manually skilled crew-member available for actual flying; (3) to reduce number of incidents which with bad luck become accidents.

Crew and Licences: No. 1, ALTP [airline transport pilot's licence], Nav., Eng., R/T. No. 2, Nav., Eng., R/T. No. 3, ALTP. These licences are given as a suggested standard under present system of examination. However, as licences are constantly under review, doubtless a system will evolve of endorsements to a basic academic and physical examination.



Suggested flight-deck layout (see letter from H. T. Thompson)

Positions: No. 1 (Captain).—Occupied only on take-off and landing or emergency; other than that of command, no flight duty necessary. No. 2.—Perform all communication orientation and direction functions. No. 3.—Manual flying and lookout; no loose-leaf navigation or mental guesstimation required.

Additional crew-members would be for relief purposes only.

It is appreciated the above might not be accepted overnight, but it is offered as a sincere attempt to give the cockpit a new look. When the most valuable members of a profession are discarded as a safety measure, change is overdue. With over 800 killed last year—long overdue.

Woking. H. T. THOMPSON.

A Famous Flying-boat

WHILE I appreciate that it may be near impossible to make note of all the famous aircraft throughout the years, I do feel rather hurt that the Short Singapore III flying-boat failed even to get a mention in your Golden Jubilee number.

These boats were, undoubtedly, among the world's most successful aircraft. They flew thousands of hours and yet had a remarkably low accident-rate. They did great work during 1935-36 while operating from Aden and other overseas stations. In fact, one squadron (No. 203) held the greatest achievement of all pre-war flying-boat squadrons, i.e., the picking-up of coal from H.M.S. *Fowey*, a sloop (then at Muscat) and flying it down the Persian Gulf to another sloop H.M.S. *Deptford* (the latter ship having run out!). Fortunately the supply was only for the ship's galley. Surely no other aircraft or squadron of that time had such a record.

I left No. 203 Squadron in 1938 on posting to India. But in 1940 those flying-boats were still doing stalwart service. They were riding at moorings in Aden as decoys—proud, noble, fine machines that rode defiantly through storm and monsoon; foxing the enemy just as well as they would have fought him.

Bravo the Singapore III! And, in particular, K4577, the oldest and most photographed of them all. Short Bros. should be as proud of building them as I am for having served and flown with them.

Devizes, Wilts. WALTER R. PEARCE.

[As to the fame of the Singapore we fully agree; but our "birthday album" was in no sense a review of celebrated aircraft—Ed.]

FORTHCOMING EVENTS

Feb. 20. Avro 504 Club: Annual Reunion, Londonderry House.
Feb. 23-24. Canadian Aeronautical Institute: Special Anniversary Meeting, Queen Elizabeth, Montreal.
Feb. 24. R.Ae.S.: "Flight Development of Aircraft before and during Operation," by Dr. A. E. Russell, C. Abell and Dr. E. Warlow-Davies.
Feb. 25. Aerodrome Owners Association: a.g.m. and Annual Dinner, London.
Feb. 25. Kronfeld Club: "Some Medical Aspects of High-speed and High-altitude Flight," by Dr. R. Wombeek.
Mar. 5. R.Ae.S. (Main Lecture, at London Airport Branch): First Fairey Memorial Lecture, "Sir Richard Fairey—an appreciation," by G. W. Hall.
Mar. 6. Helicopter Association: "The Place of the Helicopter in a Modern Army," by Lt-Col. P. W. Mead.
Mar. 7. Helicopter Association (Regional Lecture, at Yeovil): "Helicopter Activities in the Royal Navy," by Lt-Cdr. J. S. Sproule.
Mar. 7. British Interplanetary Society: "Radio Communications with a Space Probe," by Dr. W. T. Blackband.
Mar. 10. R.Ae.S.: "Water and Ice in the Atmosphere," by R. F. Jones.
Mar. 12. R.Ae.S.: 12th Louis Blériot Lecture, "The Nord Griffon; and Turbo-ramjet Power," by M. l'Ing. Gen. de l'Air Noël Daum.
June 12-21. Paris Aero Show.
Sept. 7-13. S.B.A.C. Display and Exhibition, Farnborough.
R.Ae.S. Branch Fixtures (to Feb. 27): Feb. 25, *Bristol*, C.A.A./A.R.B. Lecture, "Future Safety Requirements in Air Transport," by R. B. Meyersburg and W. Tye; *Christchurch*, "Navigation Aids," by G. E. Beck; *Hatfield*, "Development of the P.1 Aircraft," by F. W. Page; *Preston*, "Operational Problems in Supersonic Flight Testing," by R. P. Beamont. Feb. 26, *Belfast*, "Noise and its Effects on Aircraft Structures," by M. O. W. Wolfe; *Isle of Wight*, "Development of Submarines," by R. N. Newton; *Southend*, "Aircraft Electrical Installations," by G. G. Wakefield.

THE INDUSTRY

Room at the Top

WHEN Sir Frederick Handley Page spoke at the recent prize-giving to engineer and trade apprentices of Handley Page (Reading) Ltd. he firmly disposed of the idea that the only work open to an out-of-indentures apprentice was at the bench or on the factory floor. "There is always room in higher supervision and management for the man who knows his job," said Sir Frederick. "If the apprentice has made use of the knowledge available to him he will be able to qualify for the splendid opportunities that exist for well-trained personnel."

Sir Frederick commented that last year's standard of achievement, both at the factory and at the technical college, was very high; and one engineering apprentice, L. Keys, had won a State scholarship to study at the College of Aeronautics—the first Woodley apprentice to receive such an award.

When he presented the prizes the Hon. P. F. Remnant, M.P. for Wokingham, praised the apprentices for rejecting the attraction of an initially well-paid job in favour of a sound training. Echoing Sir Frederick's theme, he added: "There is always security and room at the top for those who have become skilled craftsmen in their own sphere and are prepared to be loyal."

Lightweight Airline Headsets

IN both turboprop and turbojet airliners the wearing of oxygen masks by one of the pilots thoughout the cruising portion of a passenger-carrying flight is mandatory. This has in turn led to the design of special civil headset and oxygen mask equipment designed to provide the standards of comfort and efficiency which civil crews rightly demand. Military equipment, designed to very different requirements, is not sufficiently light or comfortable and is in any case intended to afford a measure of crash-protection and pressure breathing not required in civil operations.

After some hours' continuous wear an inefficient headset can cause acute discomfort. To avoid this objection Airmed Ltd., of Harlow, Essex, designed the Strat-O-Set headset (with rigid toggle-frame attachment for an oxygen mask), users of which now include B.O.A.C. Britannia pilots. In the stand-by position the mask hangs on a toggle frame anchored to the headset by quick-release attachments at the earphone mountings. The forward tension when the mask is snapped into position is taken by a light cloth strap connecting the earphones round the back of the head.

Further development work has since led to a new toggle frame system, oxygen mask and headset which are lighter and more comfortable, and these have been given the designation Airlite. The rigid frame has been replaced by chain links terminating at the mask in a snap-over linkage by which the mask can be quickly clamped to the face. Designated type S.P.2, the mask itself is specially light and so designed that sizing is eliminated. It may be used with Types A20 or Mk 17 pressure demand regulators, providing automatic pressure-breathing at cabin altitudes above 30,000ft. (For regulators such as the A12 the S.P.3 series masks are available.) Spring-loaded quick-attachment points for the toggles are provided on the earphone mountings. The mask can be left suspended on its chains to rest on the chest and the head can be turned without swinging the mask at the same time. From the stand-by position the mask may be put on (and with one hand) in about 2 sec, or in 8 sec if it is stowed conveniently nearby.

The Airlite headset itself is formed by an arch of spring wire holding a very light headphone in a sliding clamp at each end.

Airlite headset worn with Airmed S.P.2 oxygen mask and with boom microphone; on the right the mask is seen in the "rest" position

After the H.P. (Reading) prizegiving: Sir Frederick Handley Page (second from right) talks with (left to right) L. Keys, the Hon. P. F. Remnant and A. Davies (see first news-item)

Glycerine-filled pads surround the phones, providing a close, comfortable fit. A minimum noise attenuation of 10 db under external noise levels of 97 to 100 db is claimed. A foamed plastic pad with a sealed surface and artificial leather cover bearing a user's name-plate forms a rest for the top of the head.

The fully adjustable boom-mounted microphone is arranged to swivel through 270 deg so that it may be worn on either side of the head. The P.V.C.-covered tinsel wiring conforms to official requirements and is fully screened. Customer requirements for different jacks, microphone impedances and other characteristics can easily be accommodated. The headset alone weighs 15 oz. Also available are the headset without oxygen mask or without boom microphone; and there is also a version for use in ground establishments.

Airmed inform us that they are now supplying the headset/mask for the Comet 4 fleets of B.O.A.C. and Aerolineas Argentinas and for Armstrong Whitworth Argosy crews; orders for several other fleets are in negotiation.

IN BRIEF

Vice-Admiral Sir John Eaton, K.B.E., C.B., D.S.O., D.S.C., R.N.(Ret.), has joined Marconi's Wireless Telegraph Co. Ltd. as chief of administration at the company's research and development laboratories at Great Baddow, Essex. In this capacity he will be responsible for all administrative matters to the chief of research, Dr. E. Eastwood, Ph.D., M.Sc., M.I.E.E.

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Mr. E. W. Webb, A.M.I.E.E., has joined Smart and Brown (Machine Tools) Ltd. as sales manager of the aircraft and electrical division. He was formerly sales manager of the aviation division of Elliott Brothers (London) Ltd.

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Rist's Wires and Cables Ltd., Lower Milehouse Lane, Newcastle, Staffs, have printed a display card bearing samples of their range of aircraft cables and coloured alternatively royal blue or primrose yellow.

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BTR Industries Ltd. have announced the appointment of Mr. E. R. Fuller as marketing manager for Plastidry fire, agricultural and multi-purpose hose. He was formerly with the General Fire Appliance Co. Ltd., being responsible for chlorobromomethane fire-fighting equipment.

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In 48 well-illustrated pages, *Information Bulletin No. 24* of the Aluminium Development Association (33 Grosvenor Street, London, W.1) deals with the theory and practice of bending aluminium and its alloys. Much of the contents should be of value to aircraft production engineers.

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We regret to record that Mr. J. V. Glen, who had been with the B.T.H. aero equipment sales staff at Coventry since 1936 and formed the department now known as technical sales, died recently at the age of 74. After reaching the normal retiring age he had been retained by the company as consultant and personal assistant to the sales manager.

* * *

Cossor Radar and Electronics Ltd., one of the Cossor group of companies, have now moved from Highbury and are operating from three factories at Harlow New Town in Essex. One factory on the Eastern industrial estate now houses certain special process laboratories and workshops, while another is a manufacturing unit for large-batch production of small electronic equipments. The company's only major unit now outside Harlow is the service department, which remains at West Norwood; and there is a London office at Cossor House, Highbury Grove, N.5.

UNKNOWN